HD
2766
W8

# REGULATION, VALUATION AND DEPRECIATION OF PUBLIC UTILITIES

SAMUEL S. WYER

YC 26480

LIBRARY OF

ALLEN KNIGHT

CERTIFIED PUBLIC ACCOUNTANT

502 CALIFORNIA STREET

SAN FRANCISCO, CALIFORNIA

GIFT OF
Allen Knight

SIGILLVM · VNIVERSITATIS · CALIFORNIENSIS
LVX
FIAT
MDCCCLXVIII
EX LIBRIS

Digitized by the Internet Archive
in 2007 with funding from
Microsoft Corporation

http://www.archive.org/details/regulationvaluat00wyerrich

# REGULATION, VALUATION AND DEPRECIATION

## OF PUBLIC UTILITIES

SAMUEL S. WYER, M. E.

CONSULTING ENGINEER

# REGULATION, VALUATION AND DEPRECIATION

OF

# PUBLIC UTILITIES

BY


## SAMUEL S. WYER, M. E.

CONSULTING ENGINEER

COLUMBUS, OHIO



e f o
13-28 7115
9/7/18



MEMBER:

AMERICAN SOCIETY MECHANICAL ENGINEERS,
AMERICAN INSTITUTE MINING ENGINEERS,
AMERICAN ACADEMY OF POLITICAL AND SOCIAL SCIENCE.

AUTHOR:

TREATISE, PRODUCER GAS AND GAS PRODUCERS.



PUBLISHED BY
THE SEARS & SIMPSON COMPANY
116 W. SPRING STREET
COLUMBUS, OHIO

9/25/18

HD 2766
W8

# VALUATION AND DEPRECIATION

OF

# PUBLIC UTILITIES

BY

SAMUEL S. WYER, M. E.

CONSULTING ENGINEER

DEDICATED TO
JEAN, NEAL AND RAMON

Gift of Allen Knight

MEMBER:
AMERICAN SOCIETY MECHANICAL ENGINEERS,
AMERICAN INSTITUTE MINING ENGINEERS,
AMERICAN ASSOCIATION FOR ADVANCEMENT OF SCIENCE

AUTHOR OF:
TREATISE, PRODUCERS GAS AND GAS PRODUCERS.

PUBLISHED BY
THE ENGINEER PUBLISHING COMPANY
249 W. LIVINGSTON STREET
COLUMBUS, OHIO

COPYRIGHT, 1913
SAMUEL S. WYER,
COLUMBUS, OHIO

# Chapter Subjects


1. The Public and the Public Utility.
2. Fundamental Definitions.
3. Economics of Utility Problems.
4. Governmental Power to Regulate Utilities.
5. Protection of Utilities from Adverse Regulation.
6. Requirements of Regulations.
7. Relief from Oppressive Regulation.
8. Depreciation.
9. Electrolysis as a Form of Depreciation.
10. Legal Status of Electrolysis.
11. Valuation.
12. Going Value, and Going Concern Value of Utilities.
13. Principles Governing Cost of Utility Service.
14. Engineering Data Pertaining to Utility Regulation, Valuation and Depreciation Problems.
15. Reference Data.
16. Selected Bibliography.

Name Index.

Subject Index.


# List of Reference Tables


| | | Page. |
|---|---|---|
| 1. | Present Worths | 238 |
| 2. | Future Worth at End of Various Years | 239 |
| 3. | Compound Interest Tables | 240 |
| 4. | Semi-annual Basis Sinking Fund Table | 241 |
| 5. | Annual Basis Sinking Fund or Annuity Table | 242 |
| 6. | Semi-annual Installment Payment Table | 243 |
| 7. | Metcalf's Table of Useful Life of Equipment | 243 |
| 8. | Approved Depreciation Rates | 244 |
| 9. | Pressure Unit Equivalents | 247 |
| 10. | Effect of Gas Pressure on Gas Volume | 247 |
| 11. | Effects of Altitude on Gas Apparatus Capacity | 248 |
| 12. | Reflecting Powers of Various Surfaces | 248 |
| 13. | Demand Factors for Electric Service | 249 |
| 14. | Monthly Average Time Between Sunset and Sunrise and Utility Lighting Service Use | 249 |
| 15. | Results from Removal of Water Main Growths | 250 |


# List of Illustrations


| | | Page. |
|---|---|---|
| Fig. 1. | Duplication of investment when two Utilities serve the same community on a competitive basis | 27 |
| Fig. 2 | Yearly relative prices of commodities | 28 |
| Fig. 3. | Average prices for Utility services | 30 |
| Fig. 4. | Percentage of family annual incomes spent for Utility services. | 32 |
| Fig. 5. | Typical fuel economies | 33 |
| Fig. 6. | Relative heat unit and candle power hour costs | 37 |
| Fig. 7. | Electric service load curves | 39 |
| Fig. 8. | Artificial gas service load curve | 40 |
| Fig. 9. | Natural gas service load curves | 41 |




380303

## List of Illustrations—Continued


Fig. 10. Telephone service load curves ..... 42
Fig. 11. Classification of fixed and variable charges in percentage of total operating cost ..... 46
Fig. 12. Curves showing relation of cost and number hours use of electric power ..... 47
Fig. 13. Diagram showing connections between natural gas producing strata and gas consumers fixtures ..... 52
Fig. 14. Readiness to serve features of water works fire service ..... 54
Fig. 15. Diagram showing typical connections between two telephone subscribers ..... 55
Fig. 16. Governmental powers to regulate Utilities ..... 68
Fig. 17. Protection of Utilities from adverse regulation ..... 78
Fig. 18. Requirements of Utility regulation ..... 87
Fig. 19. Relief from oppressive regulation ..... 96
Fig. 20. Species of depreciation that must be reckoned with to keep original invstment intact ..... 103
Fig. 21. Depreciation of wood by Teredo ..... 105
Fig. 22. Depreciation of wood by Limnoria ..... 106
Fig. 23. Depreciation of wood by Chelura ..... 107
Fig. 24. Depreciation of wood by Sphaeroma ..... 108
Fig. 25. Depreciation of wood by pole borer ..... 109
Fig. 26. Depreciation caused by sleet storm ..... 110
Fig. 27. Destruction of lead telephone cable by squirrels ..... 111
Fig. 28. Tuberculation or growths in water main ..... 112
Fig. 29. Depreciation of natural gas wells in Ohio ..... 119
Fig. 30. Depreciation curves ..... 122
Fig. 31. Typical composite or average life depreciation problem ..... 127
Fig. 32. Action of electrolysis ..... 132
Fig. 33. Value of current flow K in amperes ..... 137
Fig. 34. Pitting of cast iron pipe by electrolysis ..... 138
Fig. 35. Destruction of cast iron pipe by electrolysis ..... 139
Fig. 36. Destruction of steel and lead service pipes by electrolysis ..... 140
Fig. 37. Relative stray leakage currents with various return circuit conditions ..... 148
Fig. 38. Factors pertaining to electrolysis damages ..... 156
Fig. 39. Fluctuations of cast iron pipe and copper ingot prices ..... 167
Fig. 40. Calculation of going value of Utility plant ..... 182
Fig. 41. Factors determining cost of electric power ..... 187
Fig. 42. Factors determining cost of natural gas ..... 188
Fig. 43. Factors entering into freight rate determination ..... 196
Fig. 44. Engineering data ..... 205
Fig. 45. Effect of voltage variation on candle power and efficiency of incandescent electric lamps ..... 244
Fig. 46. What a complete sanitary water analysis includes ..... 231
Fig. 47. Volume of gas stored in one mile of various size gas mains ..... 251



Material for illustrations is acknowledged from the following:

Fig. 15—The Telephone News, Philadelphia, Pa.
Fig. 21. 22, 23, 24—American Society of Civil Engineers.
Fig. 25—U. S. Bureau of Entomology.
Fig. 27—Michigan State Telephone Co.
Fig. 28—National Water Main Cleaning Co., New York City.
Fig. 34, 35—Ray Palmer, Consulting Engineer, Chicago, Ill.

Law is nothing unless close behind it
stands a warm, living public opinion.
—Wendell Phillips.

# Chapter 1

## THE PUBLIC AND THE PUBLIC UTILITY

**§1 Scope.**—The generic term "Public Utility" embraces all property devoted to a public use and in which the public has an interest. It includes all cooling, drainage, electricity, gas, heating, storage, telegraph, telephone, terminal, transportation, water supply and wireless agencies serving the public, whether such service is urban, suburban, interurban, rural, intrastate or interstate. In transportation agencies it is immaterial whether the traffic is on roads, railways, water, or thru the atmosphere, or whether the motive power is animal, steam, internal combustion engines, electricity, or the wind.

**§2 Point of View.**—This book is not a partisan appeal for the rights either of the Public or the Public Utilities. Rather, it is an unbiased discussion and concise compilation of the pertinent economic, engineering and legal facts relating to both. My aim is to establish a code for both, rather than an ex parte argument for either interest.

The book is limited to the discussion of basic principles. Therefore, no reference is made to the kaleidoscopic and ephemeral regulation enactments of the different States and Municipalities. Neither can blanket rules be given that may be blindly applied—without expert legal or engineering knowledge of the local conditions—as a test for the cost of Utility service or regulation standards in any given case.

My own argument is fortified with numerous digested opinions of experts and judicial decisions, many of the latter being from the United States Supreme Court. The book is, therefore, the summation of the amassed thought and experience of many minds covering a period of many years. The source of quotations is indicated by figures—thus (200)—which refer to the bibliography given in Chapter 16.

Brevity has been my constant aim, and for its sake many quotations are condensed or paraphrased, and the generic term "Utility" generally substituted for the various species of Public Service Corporations. However, the exact meaning has always been retained.

**§3 Increasing Importance of Utility Problem.**—Utility services are the outgrowth, developers and conservers of our civilization, and form an inseparable part of our daily life. As the density of population increases, standards of living become higher and our daily life becomes less individualistic and more complex. Thus, many services, performed in the past by individuals, are now being rendered collectively for the community by a Utility, and this tendency will increase in the future. This will make us more dependent on Utility services and increases the necessity for the recognition and enforcement of correct Utility regulation principles, to prevent tyrannical action from either the Public or the Utility.

Electricity, on account of its subtle nature and spectacular manifestation, is much misunderstood. As a Utility service, it will more and more become man's servant, performing his manual tasks and conserving his energies. However, many people with more faith and enthusiasm than knowledge have over-estimated its possibilities. Fig. 11, p. 46, shows that the fixed charges on the investment required to generate electricity are very large in comparison to the cost of fuel. Many ill-fated water-power electric schemes have ignored this fundamental feature. The heating energy limitations are shown in Fig 6, p. 37.

The collective sanitary sewer system and central sewage disposal or purification plant will replace the individual privy vault and cesspool. As the dangers and economic losses from water-borne diseases and inadequate fire fighting service become more generally known, the greater will be the public demand for safe and adequate water supplies. Here, the very nature of the conditions to be met necessitates a water Utility.

The smoke nuisance in the average city is not caused primarily by the factory, but by the aggregate smoke from the homes. Smoke prevention appliances are not commercially feasible in the home, as they are in the factory, and the solution of the "smoke problem" depends on the extension of central Utility heating plants or the gas Utility service instead of burning solid fuels in homes.

The development of high pressure natural gas compression and transmission brings remote and inaccessible supplies of that best of all of Nature's fuels direct to the consumer's premises. This ren-

ders a Utility service that can never be equalled by any man-made gas and unfortunately is usually not appreciated until after the particular supply is exhausted.

Intelligence communication—by means of the telephone, telegraph and wireless—and transportation are mutually interdependent. Safe transportation is not possible without intelligence communication service, and intelligence communication is of little value without transportation. The easy and unhampered conveyance of speech, men and goods from place to place is one of the most vital factors in our national prosperity.

**§4 United States Supreme Court View of Regulation Problem.**—"Regulation of Utilities which perform their duties under conditions of necessary monopoly will occur with greater and greater frequency as time goes on. It is a delicate and dangerous function and ought to be exercised with a keen sense of justice on the part of the regulating body, met by a frank disclosure on the part of the Utility to be regulated." (485)

"The courts ought not to bear the whole burden of saving property from confiscation, though they will not be found wanting when the proof is clear. The legislatures and subordinate bodies, to whom the legislative power has been delegated, ought to do their part." (485)

"Our social system rests largely upon the sanctity of private property, and that state or community which seeks to invade it will soon discover the error in the disaster which follows. The slight gain to the consumer, which he would gain from a reduction in the rates charged by Utilities, is as nothing compared with his share in the ruin which would be brought about by denying to private property its just reward, thus unsettling values and destroying confidence. On the other hand, the Utilities to be regulated will find it to their lasting interest to furnish freely the information upon which a just regulation can be based." (485)

**§5 Public Opinion.**—"Public opinion is based on information and belief. It is but the concert of individual opinion, and is as much subject to change or to education. If it is wrong, it is wrong because of wrong information and consequent erroneous belief." (4)

"Public opinion acts upon us through the favor and disfavor, association and ostracism, approbation and disapprobation of our fellow men. It is a massive, external, intangible control." (42)

Public opinion is merely human opinion. Therefore it is not infallible and is not necessarily just or right. Like a man's conscience,

it is a creature of education. The preponderent public opinion, both learned and illiterate, during the time of Columbus was that this world was flat instead of spherical as claimed by Columbus; however, Columbus was right and public opinion was wrong.

It is the duty of all Utilities to see that the public has correct information regarding the Utility problem. This will develop a fair public opinion which will soon be reflected in just and equitable legislation. On the other hand, false statements or distorted facts will quickly produce erroneous beliefs, resulting in a vindictive public opinion which will crystalize into irrational and injurious legislative expedients.

**§6 Public Opinion and Custom.**—"Custom is the uniformity of conduct of all persons under like circumstances. Custom is what is generally practiced in a community and believed by the community generally to be a proper practice. Hence, it is not opinion but practice and is effectual only when it is universal or nearly so." (50) Utilities must frequently recognize this in their dealings with the public.

**§7 Public Opinion and Law.**—"It is almost a truism that the spirit of the age molds its law. The continual development in common law is largely the result of progressive changes in public opinion. The seasoned opinion of a given era soon becomes the law of that period; for the judges usually have the same general ideas as other enlightened persons, and they have the power to insist that other men shall act according to their notions of social justice. Whenever the mass of men firmly believe that approximation to certain ideals is necessary for their salvation, these policies will almost always be found to have become fundamental principles of the law." (14)

**§8 Economics and Legal Changes.**—"The underlying causes of most of the changes in the law are really economic. Men suffer from the conditions of the time; and they look to the law to save them from their fate." (14)

**§9 Mutual Interest** (108).—This is most vital, and is summarized as follows:

1. "The Utilities and the public have such intimate business relations that a blow at either must necessarily injure the other seriously.

2. "The courts have defined quite clearly the legal relation existing between the two interests.

3. "A proper spirit of mutual confidence is lacking, and the two interests at the present time are generally hostile.

4. "There have been errors and abuses on the part of both Utilities and the Public.

5. "The capital invested in Utilities is and should be the money of the people, and should be safeguarded to prevent its loss by manipulation, and to insure a fair return."

**§10 Co-operation Between Public and Utilities.**—No Utility can be permanently prosperous without the co-operation of the Public; in fact, the Utility and the Public are in close partnership. Having thus entered into virtual contractual relations, it is but right that mutual expectations should be raised, that each should know what to expect from the other, and that fair expectations should not be disappointed.

**§11 Fair Profits and Reasonable Rates.**—"A fair and reasonable profit is just as essential, in the long run, to the Public's interest as a fair and reasonable rate. Unless this fact is realized practically in public opinion and in legislation, investment in Utility enterprises will so diminish that the country must suffer seriously, both in present convenience and in future growth. The people and the Utilities lose by the folly, and profit by the wisdom of either." (34)

**§12 Reciprocal Relation of Utility and Public.**—"The duty of the Utility towards the citizen, and that of the citizen towards the Utility, is somewhat reciprocal, and any rule or regulation or course dealing between the two parties, which does not secure the just rights of both, ought not to be adopted, and cannot receive the sanction of the courts." (574)

**§13 True Relation of Utilities and Public.**—"What is needed is a clear comprehension, on the part of both the Utilities and the Public, of the true relation a Utility occupies to the public which it serves. The idea that a Utility is purely a private business enterprise is a popular fallacy often entertained by both parties. The property of such a concern is private, but the use to which it is put is public. In the use the public has a vital interest. Controversies arising between the Public and the Utility as to the conduct of the business, if not capable of adjustment by mutual agreement between the parties, should be left to the proper tribunal for determination, and neither party should jeopardize the public interest by any action designed to coerce the other party into submission to the former's views. Otherwise both parties are likely to suffer in the end, because of protracted controversies and retaliatory actions." (728)

**§14 What Is Utility Regulation?**—Utility regulation is the branch of legal science that defines the rights and duties existing between the Public and the Public Utility. The function of regula-

tion is to establish and enforce the duties, maintain and protect the rights of both, and prevent either from tyrannizing over, or otherwise injuring, the other. Thus, regulation preserves private property interests by reconciling them with public right.

Regulation is not a cudgel to be used by either interest over the other, but a code to be observed by both. To be permanently effective, it must be just and equitable. The State's duty to protect is just as clear as its duty to control. Furthermore, you cannot found and maintain a business unless you have a law to protect it.

**§15 What Regulation Is Not.**—The popular but erroneous conception of regulation is that it is an arbitrary governmental power to make a Utility yield to legislative control or caprice. However, this is far from the truth. Such governmental power is not regulation, but tyranny, and would result in anarchy.

"When we consider the nature and the theory of our institutions of government, the principles upon which they are supposed to rest, and review the history of their development, we are constrained to conclude that they do not mean to leave room for the play and action of purely personal and arbitrary powers." (448)

**§16 What Caused Demand for Regulation?**—"The aggressive, almost insolent, and oftimes unfair attitude of some Utility corporations has created an insistent demand for further and more direct control of operations than has been possible thru the usual form of legislative enactment. The American people are not, as a rule, over-inquisitive as to somebody else's business, but when imposed upon they do not hesitate to ascertain the why and wherefore. The result has been a publicity of corporation finances and affairs that now implies an obligation to afford the corporations legitimate protection in business." (97)

**§17 Results of Remedial Action.**—"All history shows that a particular grievance suffered by an individual or a class, from an oppressive or defective law, or the absence of any law touching the matter, is often the occasion of and cause for enactments general in their character, designed to cover cases not merely of the same, but all cases of a similar, nature." (511)

**§18 Attitude of Utility Officials.**—Fair minded and progressive Utility officials do not oppose rational regulation, but recognize and endorse it. "Public control or regulation of Public Utilities by permanent Commissions has come and come to stay." (4)

"Regulative authority there must be, but it must be consistent and governed by the rule of fair play. The duty of the good citizen toward the Utility is to insist that it shall be punished when it goes

wrong and protected in the possession and enjoyment of its property and in the performance of its public functions when it is right. Make the Utilities render a fair service for a fair price, and permit them to earn and keep a fair return." (34)

**§19 Source of Regulation.**—The science of regulation has arisen out of the difficulties caused by the violation of true economic and legal principles by both the Public and the Utilities, and every advance in regulative science has originated in some evil. "It is a sound principle of jurisprudence that all law is based upon the previous conception of the necessity thereof and that such law has either been violated or is capable of violation." (65)

Regulation is a form of the common law. Hence, "it is a body of principles, general in their application, which are extracted from the cases, and which illustrate the same, and constitute evidence of what the rule of law is when desired in the solution of other cases." (35)

Since regulation is a form of the common law, it "includes those principles, usages and rules of action applicable to the government and security of persons and property, which do not rest for their authority upon any express and positive declaration of the will of the legislature." (456)

Many cases involving regulative principles have been decided by the United States Supreme Court. The dicta laid down in these decisions, which are the evidence of what the law is, and from which of course there is no appeal, form the basis for regulation, in that they clearly and authoritatively define the relations between the Public and the Public Utility. These dicta are logically divided into four groups, and are given in Chapters 4, 5, 6 and 7.

**§20 Distinction Between Law and Legislation.**—Law is the science which shows the line of demarcation between right and wrong, and its function is to establish right and to prevent or punish wrong. "The mission of law is to teach, direct and conserve, and it is mandatory, prohibitory and permissive." (65)

Legislation is merely an implied expression of popular will, and may or may not be in conformity with law. Hence, law and legislation are not synonymous. "Some legislation is not so much law as tyranny. Among the evils which oppress society, there are few greater than those caused by legislative expedients undertaken in ignorance of what the true nature and function of law are." (37)

There is a vast difference between form of law and substance of law. "Everything that may pass under the form of enactment is not law of the land." (284) "Legislators too often have displayed an

ignorance or disregard of existing laws, spreading the idea that new legislation was a cure-all for any undesirable condition, while it was often only a political play." (4)

Much of our legislation not only fails to conform with law, but is not even accurate English. Nearly every legislative session leaves its aftermath of loosely or ambiguously worded enactments that must be construed by the courts before they can be safely used.

**§21 Distinction Between Utility Regulation and Legislation.**—Utility regulation, like law, is not necessarily synonymous with legislation; for regulation is a science based on eternal laws and universal, long-established and recognized principles of justice and equity; while legislation is anything that may be enacted, regardless of the rights involved. Furthermore, the primary motive for legislation is frequently political expediency, rather than equitable relief, and it usually reflects ephemeral radical sentiment.

**§22 Does Regulation Control Liberty?**—Most of the protests made against governmental regulation of Public Utilities are predicated on the alleged resulting curtailment of liberty. This arises from the fact, which so many do not appreciate, that liberty and license are not synonymous. Excess is always ruin, and law and liberty are inseparable. In fact, rational regulations preserve men free by stinting their liberties, for where law ends tyranny is sure to begin.

Liberty is much talked of, but little understood. The average man's conception of it depends on his heredity, environment and education, the last two being susceptible of great modification by circumstances. The Puritan's idea of liberty was—"the right to worship God according to the dictates of his own conscience and make every one else do likewise." The Frenchman's conception of liberty is—"the right of every man to be master of the rest." It is obvious that a self-centered conception of liberty results in either tyranny or license. A part of every man's liberty is surrendered upon his entering society, as the purchase price for the superior advantage of society. Further, as soon as any part of one's conduct affects prejudicially the interests of others, society has jurisdiction over it.

"Man is organized restriction; restraint seems to be as beneficial as law itself. The prohibitions of law promote the highest interests of society. The law of limitation is as prevalent as law itself." (65)

**§23 Interests of Public Superior to Private Property Right.**—"It is a settled principle, growing out of the nature of well-ordered civil society, that every holder of property, however absolute may be his title, holds it under the implied liability that its use may be so regu-

lated that it shall not be injurious to the equal enjoyment of others having an equal right to the enjoyment of their property, nor injurious to the rights of the community." (424)

"There is no such thing in civilized society as the unrestrained power to contract. Every man surrenders some of his individual rights when he associates with or becomes a part of any society or government, and the power of the government is complete to legislate so that, while according to every man the fullest possible liberty to do what he pleases with his own, he must not interfere with the similar rights of others." (612)

**§24 Regulation Must Not Contemplate Management.**—To secure the most effective results, the scope of regulation must be the least possible to insure adequate protection to the public. The efficacy will always decrease as the scope is unnecessarily increased.

Regulation must be supervisory rather than prescriptive; and its power must be curbing rather than directional, and must stop where operation begins. In brief, it must comply with the dictum that "that government is the best which, while performing all its duties, interferes the least with the lawful pursuits of its people." (316)

"Management or operation requires intimate knowledge and experience which can be gained only by continuous, active and practical participation in actual working, while regulation can be intelligently exercised, after judicial hearing, by those who have not the knowledge or experience to operate." (4)

"The boundary lines between State intervention and individual enterprise must be determined by a wise expediency. The great end to be sought is that private enterprise should be left wholly free and unhampered. Any unnecessary dependence on the government for objects obtainable by private effort is so clearly a violation of Nature's law that bad results are sure to follow." (49)

**§25 Fair Attitude Toward Utility.**—"It is necessary for all men trained in straight thinking to cry out for fair dealing, as between the Utilities and the Public which they are established to serve. No engineer does his duty who does not stand with fidelity for equally square treatment for and from these Utilities. These Utilities are not here as vampires on society, but are here to serve the needs of the people in a reasonable and businesslike way; and their proper objects cannot be accomplished unless they are treated with reason and established in confidence. They obtain their income from serving the public, and they cannot give generous service unless they are granted generous opportunities. When under reasonable restraints and supervision, as by properly constituted public commissions, they

are more quickly responsive to public sentiment than could reasonably be expected of any publicly owned business organization of equal magnitude which could exist under our political conditions, and their usefulness is proved beyond contradiction." (98)

**§26 Cardinal Principles of Utility Rates** (185).—"There are four general principles that cannot be safely departed from when considering rates of a Utility. These may be stated in the following:

1. "The Utility is granted certain privileges by the public for the purpose of enabling it to furnish readily some type of service to the people, and it should be expected to furnish services fitting the needs of the people, good of its kind, and at prices which are reasonable when judged by the conditions."

2. "The Utility must not be unnecessarily harassed, but must be afforded reasonable opportunity for economically transacting the business related to giving the service for which the Utility was organized; and it must be allowed to make sufficient returns on its investment to enable it to attract the best and fairest minds to the management, and maintain a position of stable credit with the investing public."

3. "A Utility in a new and developing country must see before it opportunity to earn returns on its invested capital which are large compared with those adequate in stable and thickly settled regions. in order that it may secure the capital needful for developing its plant and extending its service to meet the apparent needs of an expanding but not yet stable population.'

4. "A new Utility, run in a stable country, ought to earn more than current rates of interest for its investors whose enterprise enables them to take the risks of establishing the business, but the rate of return on the investment may be expected to approach current rates of interest after the business has become profitable and is firmly established on fixed franchise rights covering a long period."

Definitions are the basis of systematic reasoning.
—Aristotle.

# Chapter 2

## FUNDAMENTAL DEFINITIONS

**§27 Importance of Definitions.**—Loose nomenclature is always productive of ambiguity. The mixture or multiple use of terms is the starting point for most erroneous conclusions, and Bacon's truism that "important discussions often turn upon controversies about words and it would be more prudent to begin and bring them into order by definitions" is especially pertinent to our subject.

**§28 Requirements of a Satisfactory Definition.**—This is four-fold, namely,— 1. inclusiveness; 2. exclusiveness; 3. simplicity; and 4. brevity.

**§29 Depreciation.**—The generic meaning of depreciation is a diminution, shrinkage, lessening or reduction of worth. Its various species are discussed in Chapters 8 and 9.

**§30 Amortization.**—This term should be applied only to the laying aside of funds at a fixed rate for the replacement of capital investment or the extinction or reduction of a debt. Thus, amortization deals with the repayment of the original investment, and its object is to maintain the integrity of the investment.

**§31 Distinction Between Replacement and Amortization.**—"There is a clear distinction between amortization and replacement. The amortization deals with the repayment of the original investment. This may be in installments in uniform or unequal annual amounts, or in a lump sum at the end of useful life." (111)

The replacement may mean the substitution of a new identical plant, but at a cost dependent on new conditions, or it may mean the substitution of new devices rendering equivalent service. In either event the replacement may be at a greater or less cost than the original cost, with, therefore, a corresponding increase or decrease of capital invested. The expenditure for replacement is amortization only to the extent that it retires capital already invested." (111)

**§32 Sinking Fund.**—This is a fund raised by regular contributions—monthly, semi-annual or annual—for the sole purpose of keeping the investment intact, by providing means for paying off funded debts, repayment of original investment or other accrued liabilities.

**§33 Distinction Between Depreciation and Amortization.**—Depreciation represents a physical state and not an actual expenditure. Amortization is an actual cash reserve to offset the diminution of worth resulting from depreciation.

**§34 Distinction Between Depreciation and Alteration in Value.**—This is clearly defined. "Depreciation is in reference to itself, or internal quality. Alteration in value always refers to some other commodity or external quantity." (25)

"An alteration in value of any commodity means that the quantity of it which was considered as the equivalent for a certain amount of another commodity has undergone a change. Depreciation means that it is not really of the quality it professes to be." (25)

**§35 Appreciation.**—This is an increase in worth.

**§36 Capital.**—This term means all property devoted to the rendering of the services which are the purpose of the Utility.

**§37 Fixed Capital.**—Capital which has an expectation of life in service for more than one year is called fixed capital.

**§38 Floating Capital.**—Capital other than fixed capital is called floating capital.

**§39 Property** (25).—Property, in the legal and economic sense, means the absolute, entire and exclusive **right** to anything. It embraces:

1. Material things.
2. Labor or services. } Intangible.
3. Rights. }

**§40 Cost** (22).—Cost represents actual outlay of money or its equivalent; it is a fact and is fixed.

Cost and investment are synonymous. However, in Utility valuations it is especially important to keep in mind that cost is not synonymous with value, and bears no definite relation to value or any of the species of value.

**§41 Species of Cost.**—The different species of costs relating to Utility valuation and regulation are as follows:

1. Promotion.
2. Organization.
3. Interest during construction. } Intangible.
4. Taxes during construction. }

5. Physical property.
6. Plant or original.
7. Extension.
8. Fixed.
9. Running.
10. Replacement or renewal.
11. Repair.
12. Maintenance.
13. Deferred maintenance.
14. Reproduction or replacement.

**§42 Intangible Cost.**—This is the cost of the intangible part of the property. See §479 and §480.

**§43 Promotion Cost.**—This pays for the conception of the idea, its definite development, and the financing and organization of the corporation ready to begin construction work.

**§44 Organization Cost.**—This is the cost of directing the Utility's affairs during the construction period of the plant.

**§45 Interest During Construction Cost.**—This is the interest accrued or paid on the money invested in the plant, up to the completion and starting of the plant.

**§46 Taxes During Construction Cost.**—This is the cost of the taxes that accrue or are paid, up to the completion and starting of the plant.

**§47 Physical Property Cost.**—This is the actual money spent for material and labor. What it embraces for different Utilities is shown in Figs. 41, p. 187, and 42, p. 188.

**§48 Plant Cost or Original Cost.**—These terms are synonymous, and are the sum of the intangible and physical property costs.

They represent the total cost of the plant ready to begin business, but without any business to go on. It is also evident that the additions or extensions made after the plant is started increase the plant cost.

**§49 Extension Costs.**—These are the additional expenses incurred for extending the original plant to meet the needs of new business.

**§50 Fixed Costs.**—These are the fixed annual expenses that must be met in order to maintain the integrity of the investment, and accrue regardless of the volume of service rendered by the Utility.

They receive their name from the fact that they are immutably fixed by economic conditions, and for this reason they are by far the most important elements entering into Utility rate determination. What they embrace is shown in Figs. 11, p. 46; 41, p. 187; and 42, p. 188.

**§51 Running or Variable Cost.**—This is the money spent in keeping the plant going. It is variable, and depends to a limited extent on the amount of business. What it embraces for different Utilities is shown in Figs. 11, p. 46; 41, p. 187; and 42, p. 188.

**§52 Replacement or Renewal Costs.**—These terms are synonymous, and represent expenses incurred to replace or renew parts of a plant.

Maintenance and repair costs are simply species of renewals.

**§53 Repair Costs.**—Repair costs are expenses incurred to restore the operative efficiency of the plant, subsequent to, or as the result of, a break in the plant.

The term "repairs" should not be applied to any mechanical or physical changes which result in new structures or equipment, or in such reconstruction of the old structures or equipment as makes them of greater capacity than they were originally. All costs for the changes just referred to should come under extension costs.

**§54 Maintenance Costs.**—Maintenance costs are expenses incurred for renewals in anticipating, avoiding, or preventing a break-down. They can retard depreciation, but cannot eliminate it. Their object is to keep the inevitable wear within the normal limits referred to in §318.

**§55 Distinction Between Repairs and Maintenance.**—There is a clear line of demarcation between repairs and maintenance. Maintenance costs are for prevention purposes, while repair costs are for remedial purposes. All maintenance costs are for renewals, but not all renewals are maintenance.

Repairs arise only from the use or abuse of the equipment, while maintenance costs arise whether the equipment is used or not used. Hence, maintenance comes under fixed costs, and repairs under running costs.

**§56 Deferred Maintenance.**—This is the expenditure necessary to restore a property to normal operation condition when it has been allowed to run down, due to inadequate maintenance.

**§57 Reproduction or Replacement Costs.**—These terms are synonymous, and represent the cost of reproducing the property, with new equipment, of the same class as is found in the old plant, and of the nearest type that can be purchased in the open market.

**§58 Plant Worth.**—The plant worth at any time is the plant cost plus extension cost, arbitrarily increased or decreased, for the appreciation or depreciation that has taken place in the interval between the completion of the plant and the time when the plant worth is wanted.

It is obvious that, at the completion of the plant, the plant worth would be practically the same as plant cost. It is also important to note that the plant worth is not definitely related to utility value or any of the species of value.

**§59 Value.**—Value is the capacity to incite desire for; it depends solely on want or demand, is variable, and may be more or less than cost.

"Value is an affection of the mind, and the sole origin, source and cause of value is human desire. Value is a substance which measures the estimation in which men hold things. When there is a demand for things they have value; when there is no demand there is no value." (25)

**§60 Measure of Value** (25).—The measure of value is simply the measure of the intensity of desire, want or demand and varies directly with it.

**§61 Distinction Between Value and Price** (22, 25).—A price is a fact; it is an expression of value in terms of money.

Price is not synonymous with value, or any of the species of value, for a value is only an estimate of what a price ought to be. Hence, value is always a question of opinion and not of fact.

**§62 Relation of Value and Use.**—"The value of property results from the use to which it is put, and varies with the profitableness of that use, present and prospective, actual and anticipated. There is no pecuniary value outside of that which results from such use." (396)

**§63 Species of Value.**—The different kinds of value pertaining to Utility valuation problems are as follows:

1. Scrap or junk value.
2. Salvage, second hand or re-sale value.
3. Wearing value.
4. Service value.
5. Potential value.
6. Going value.
7. Going concern value.
8. Present or fair market value.

**§64 Scrap or Junk Value.**—"All physical property, unless offset in whole by cost of removal, has a certain scrap or junk value, beyond which there is no depreciation. Hence, physical property can deteriorate only until it reaches its scrap value. This value is simply the fair market price that a purchaser will pay for the property in its disintegrated condition." (97)

The factors governing total removal cost are as follows:

1. Dismantling of equipment.
2. Transportation.
3. Usually a profit for a junk dealer.

In nearly every case, especially with improved streets, the cost of removing water or gas mains, transporting them, and leaving the surface of the street in a satisfactory condition, will be more than the market scrap value of such mains. Hence, there may be many instances where physical property does not even have a realizable scrap value.

**§65 Salvage, Second Hand or Re-sale Value.**—Sometimes equipment in good working shape may not be adapted to one plant, and yet could render good service in another. The demand for such equipment, less the total removal cost given in §64, will be the realizable value.

**§66 Wearing Value.**—This is the difference between the original cost and the scrap value.

**§67 Service Value.**—"Property, honestly and intelligently purchased with a view to its suitableness for the service intended, aside from some hidden defect or untoward accident, maintains its original value practically throughout its life, except for such deterioration as results from wear and tear or deferred maintenance." (97)

**§68 Distinction Between Wearing and Service Value.**—This is clearly defined. Wearing value refers to the physical condition only; service value combines wearing value and adaptability for specific uses. We may have wearing value without service value, but cannot have service value without wearing value.

**§69 Potential Value.**—This is the value that may come thru future growth or economic change, and is largely the substance of of things hoped for.

**§70 Going Value and Going Concern Value.**—No simple definition of these terms can be given without a thoro knowledge of the conditions upon which they are based, as shown in Chapter 12.

**§71 Fair Market Value** (134).—This is the price accepted by an owner willing to sell to a purchaser willing to buy at a fair price, and at a sale that is not forced nor governed by circumstances other than the value of the property by itself.

**§72 Utility.**—Utility is the power or capacity to satisfy a human want. It bears no definite relation to cost or value. The utility of a plant or part of a plant may be zero yet it may have a re-sale or scrap value.

**§73 Appraisal and Valuation.**—These terms are synonymous, and indicate the work of determining the present value of property.

**§74 Promoter.**—"A promoter is one who brings together the persons who become interested in the enterprise, procures subscriptions, and sets in motion the machinery which leads to the formation of the corporation itself." (451)

**§75 Gross Earnings of Utility.**—These include all the receipts arising from the company's operations as a Utility, but exclude those arising from investments or business not directly connected with Utility service, or fictitious receipts for services that the Utility has rendered itself. (325)

**§76 Net Earnings of Utility.**—"Net earnings, within the meaning of the law, are ascertained by deducting from the gross earnings all the ordinary expenses of organization and operation and expenditures made bona fide in improvements and paid out of earnings and not by the issue of bonds or stock, but not deducting interest paid on any of the bonded debt of the Utility." (325)

**§77 Break-Down Service.**—This is the service which a Utility renders when it provides a "connection" between its system and the installation of a consumer having his own plant, and agrees to stand ready to supply such consumer with service whenever his plant actually breaks down, in whole or in part. (679)

**§78 Output Expenses.**—These are expenses which vary with the use of service rather than any other factor.

**§79 Demand Expenses.**—These are expenses which are determined by the demand which the Utility must meet.

**§80 Consumer Expenses.**—These are caused directly by the consumers that are connected.

> The laws of nature are simply statements of the orderly condition of things in nature, what is found in nature by a sufficient number of competent observers.
>
> —Prof. Henry Drummond.

# Chapter 3

## ECONOMICS OF UTILITY PROBLEMS

**§81 Supremacy of Natural Laws.**—Bacon's pertinent observation that "nature is subdued only by submission" is too generally ignored. Few appreciate the fact that man is no lawgiver to nature, but merely an absorber or adapter. Nature always stands firm, and man must accommodate himself to her conditions.

"Natural Law in the business world is not a different law from that which runs thru physics, mechanics or chemistry. It is but one of the many subdivisions of Universal Natural Law. In other words, the principles which reign in the department of economics are not artificially fenced off in a field by themselves, but they have a most intimate connection with all the other subdivisions of orderly facts." (49)

"The laws of trade are as certain in their operation as the law of gravitation. You might as well try to set a broken arm by statute as to change an economic law by legislative enactment. We have been, as a nation, too ready to look to State and Federal legislation for remedies beyond their power to give. You may obstruct and delay for a time, but in the end the inexorable law of experience and survival of the fittest will prevail. That is a law of universal operation, and in its working it appears to be eternal." (34)

**§82 Conflict of Natural and Human Law.**—"The laws of nature are independent of human opinion. A discoverer in chemistry does not make the natural law which he discovers. The discovery in no way affected the natural law, the existence of which was entirely independent of human opinion. However, the law of the land is made up of human opinion. Expressions of human opinion are its sources, and an important class of those expressions of opinions are the declarations of the judges." (50)

Most human laws spring from custom or public opinion. Since neither custom nor public opinion is infallible or conclusively correct—see §5 and §6—it is easy for many human laws to be in conflict with natural laws and therefore wrong. This is especially true with regard to the economic features of Utility problems.

**§83 What Is Monopoly?**—Monopoly is anything which confers a special and peculiar economic privilege upon those who enjoy it.

**§84 Odium of Monopoly.**—Special privileges are generally regarded with suspicion. To most people monopoly and oppression are synonymous. This abnormal attitude is the result of so abusing the power of monopoly that its true status and rights are frequently ignored.

**§85 Monopolies and Regulation.**—"Utilities should be recognized as monopolies and treated as such, but under regulation conditions. For it is agreed that regulation is the necessary concomitant of monopolization." (14)

"A monopoly under governmental supervision may better promote the public interest than the freest competition. But it must be closely watched; how closely, is the important question." (3)

"The dread of monopoly and its possible abuses is natural. Unrestrained monopoly is something that may well be feared. But should we attempt to impede economic and industrial progress for fear new conditions incident to progress may make it possible for undesirable things to happen? Rather is it not the way of wisdom to prepare the freest possible road for the course of progress and at the same time, or as occasion may arise, to provide regulations that will direct in the right channels for the public good the unified and well co-ordinated activities that modern progress implies? Recent economic history indicates that there is little ground for the fear that monopolies may become so powerful as to direct the conduct of governments. On the contrary, the more effective the tendency to monopoly the more practicable becomes its regulation." (174)

**§86 Classes of Monopolies.**—There are three:

1. Artificial or social monopolies, produced by controlled unity of action, popularly called trusts.

2. Natural or virtual monopolies, resulting from strategic position; this embraces practically all Utilities.

3. Legal monopolies, created by legislative grants; this embraces all Utilities having exclusive franchises or charters.

**§87 Artificial or Social Monopolies.**—"The idea of monopoly is not now confined to a grant of privileges, but is understood to include

a condition produced by the acts of individuals and the suppression of competition, by unification of interest or management, or through agreement and concert of action." (468)

**§88 Natural Monopolies.**—"Practically all Utilities are so situated that but one can economically and satisfactorily serve a community. It is coming to be generally recognized that monopoly control may be very beneficial to the public if one company can be placed under such public regulation and control as will secure for the public a fair share in the many benefits arising from unified management. That competition cannot be depended upon to protect the consumer from high prices and poor service has been fully demonstrated." (680)

"In the case of parallel, adjacent or contiguous transportation Utilities, better service can be rendered, at a lower cost to the consumer and higher profit to the producer, under centralized management than is possible under competitive conditions. For, a single organized company can put lines just where they are needed; if the same service is performed by two companies, there will be unnecessary duplication of lines in some places, and failure to build needful ones in others; while the train times and connections will be arranged, not with regard to the maximum convenience of the public, but with a view to increase the business of one competition at the expense of the other." (22)

The cost of the distributing equipment for furnishing electric, water, gas or telephone service is such that any duplicate distributing system becomes a public burden.

The desirability of monopolistic conditions is especially marked in the telephone field. "So much of the advantage of the telephone service to each subscriber lies in the power of reaching all other subscribers that the existence of two competing exchanges in the same city destroys the usefulness of both." (22)

**§89 Legal Monopolies.**—The grant of an exclusive franchise is within the discretion of the legislature. However, "exclusive rights to public franchises are not favored. If granted, they will be protected, but they will never be presumed." (331)

**§90 Judicial Views of Monopolies.**—Numerous prevailing court decisions on the three classes of monopolies summarized, are against artificial monopolies but in favor of natural and legal monopolies:

1. Artificial or mere monopolies are odious and against common right. (341)

2. From the very nature of the case, Utilities are natural monopolies. (416)

3. Legal monopolies will be protected, but never presumed. (331)

**§91 Failure of Competition.**—"Public Utilities, whether in public or in private hands, are best conducted under a system of legalized and regulated monopoly." (203)

"If there is one thing above all others that the Utility business has established, it is that competition as a guarantor of good service and a regulator of rates has failed." (680)

"Active and continuous competition between Utilities, furnishing the same service to same locality, seems to be out of the question. This has been shown by experience. Such competition is also contrary to the very nature of things. Two distinct and separate corporations are not likely to remain separate very long after it becomes clear that the services rendered by both can be more cheaply and more effectively furnished by only one of them." (688)

Citations 661 to 674 inclusive and 676 also sustain the argument of this section.

**§92 Cost of Rate Wars.**—"Competition ultimately results in higher rates. In this way it often happens that the means which were thought to be the preventative of onerous conditions become the very agents through which such conditions are imposed." (688)

"After a war of rates, competition ceases, and we find rates higher; for the companies, when they agree to cease competition, usually succeed in re-arranging their capital in such a way as to convert the losses suffered during the rate war into share capital." (120)

"Competition is sure to be expensive, even tho for a time apparently economical or profitable. We may confidently expect losses in the conduct of the business and the struggle for a control of the situation; and profits in the later union or consolidation, to be later converted into new capitalization as a perpetual and irremediable burden on the public. The temporary advantage to a portion of the public is reasonably sure to be followed by an undue burden upon the public as a whole thru the larger capital demanding a return, much of it representing unnecessary duplication of properties as well as losses." (672)

"Rate wars mean lower than paying rates, failure to keep the property in proper operating conditions and inadequate service. In one way or another losses and destruction due to rate wars are almost certain to fall on the public. Rate wars in the Utility field are so clearly against public policy that they should under no circumstances be permitted." (732)

**§93 Duplication of Investment in Competing Utilities.**—The approximate percentage of total investment—including pro-rated intangible cost—that is duplicated when two Utilities are installed to render the same service to the same community is graphically shown for six different Utilities in Fig. 1, p. 27. In the case of competing telephones it is necessary to place the instrument cost in the duplication because every subscriber that wishes to reach any other subscriber in the same community must have the use of the duplicate instruments. On the other hand, the cost of a 10,000 subscriber board would be more than the cost of two 5000 subscriber boards; see §151.

**§94 Limited Field for Utilities.**—A manufacturing plant has the world for its field; and if the market conditions are unsatisfactory in one place the output may be marketed elsewhere. But a Utility is limited to a relatively small fixed territory, and is dependent on the local market conditions for the sale of its service along its service lines. In the case of artificial gas, cooling, electric lighting and power, heating, natural gas, telephone and water Utilities, an additional investment must be made for each new consumer. This natural limitation must be considered in all rate determinations.

**§95 Importance of Correct Location.**—Correctness of location is of more importance to a Utility than any other factor. A properly located but weak Utility may be rejuvenated, but if the location is wrong the task is hopeless.

A Utility is capable of furnishing the particular species of service that the plant is designed for, and nothing else. Most of the equipment is so special and fixed in its nature that it cannot be moved elsewhere. If there is no demand for its services, the plant is worthless, and the investment is lost.

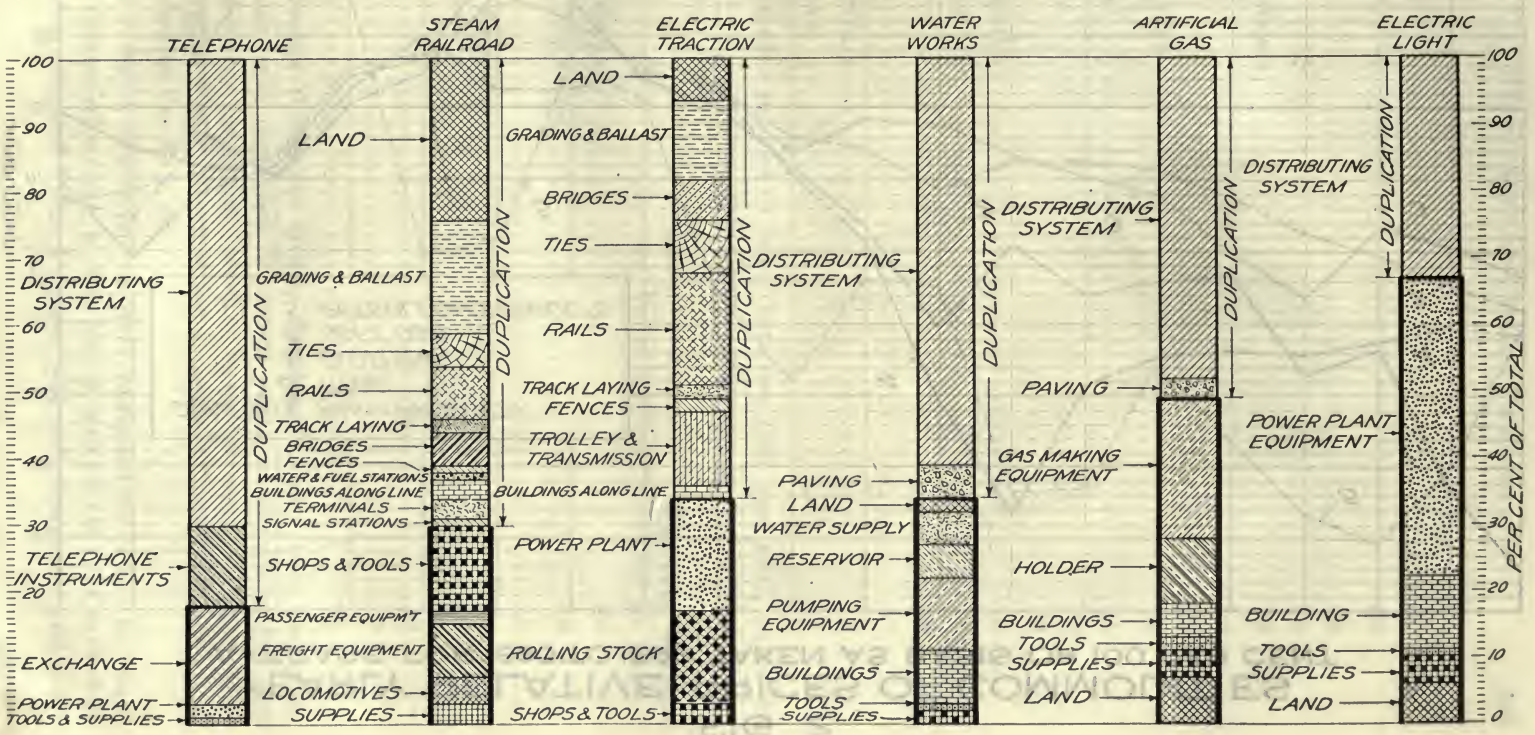
**§96 Significance of Extension Costs.**—Every normal or growing Utility must be constantly making extensions and in this way adding to its original investment. A Utility distributing system is never finished, and is never constant for any length of time as to investment per consumer. In the case of electric, gas, heating, telephone and water service, an extension cost must be incurred for each new consumer.

**§97 Relative Prices of Commodities.**—These are shown in Fig. 2, p. 28. The data for curves 1, 2, 3, 4 and 5 were taken from pages 466, 473, 483, 484 and 485, respectively of (271).

**§98 How Labor Cost of Utilities Has Increased.**—The increase in cost of labor between 1900 and 1910, based on the average of all railroads in the United States, is as follows: (276)

# FIG. 1

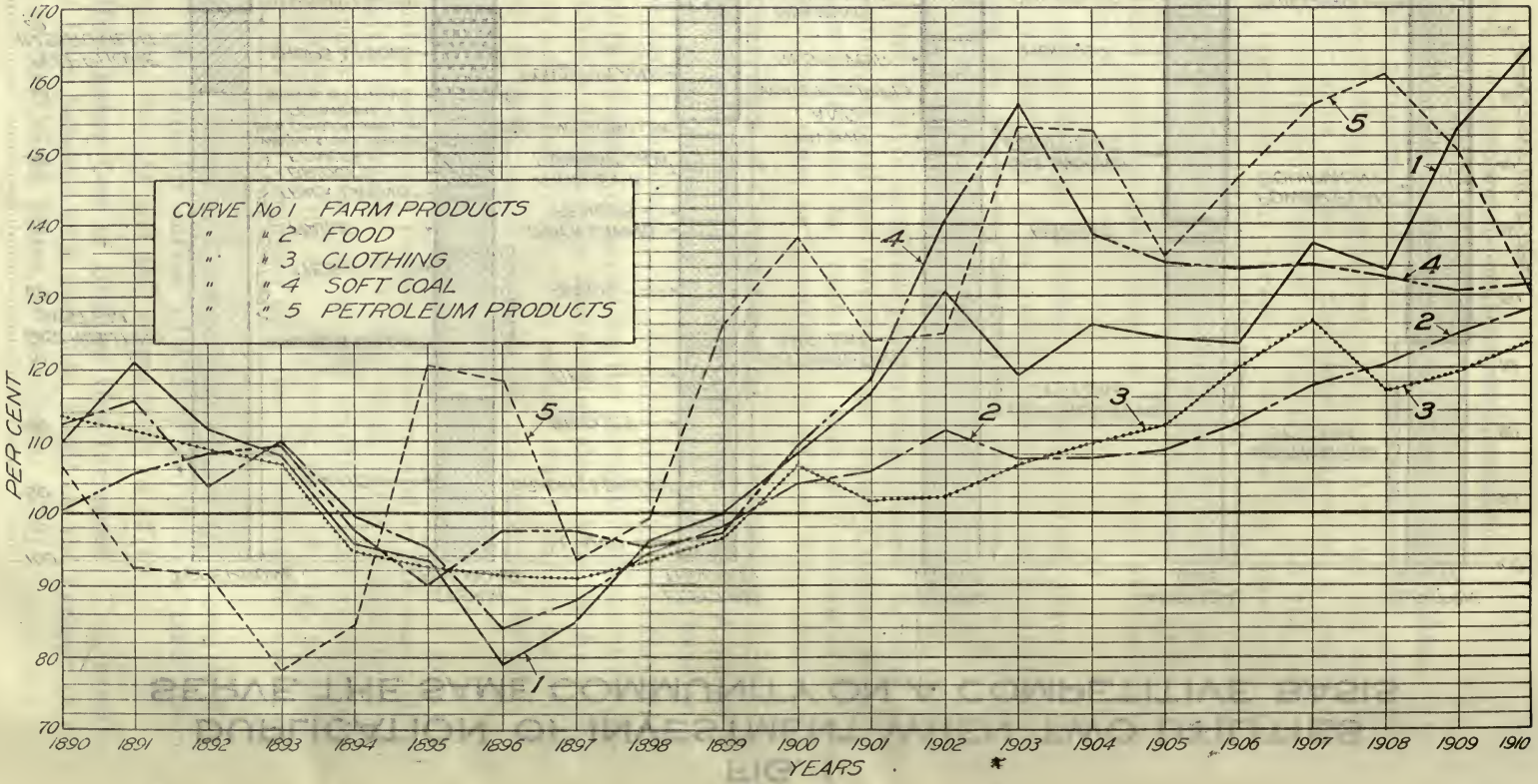
## DUPLICATION OF INVESTMENT WHEN TWO UTILITIES SERVE THE SAME COMMUNITY ON A COMPETITIVE BASIS



# FIG. 2

## YEARLY RELATIVE PRICES OF COMMODITIES

### AVERAGE FOR 1890 TO 1899 TAKEN AS BASIS OR 100 PER CENT



| Class | Per cent increase 1900 to 1910 |
|---|---|
| Trainmen | 36 |
| Machinists | 35 |
| Firemen | 28 |
| General Officers | 28 |
| Shopmen | 26 |
| Carpenters | 23 |
| Conductors | 22 |
| Enginemen | 21 |
| Trackmen | 20 |
| Officers | 20 |
| Station Agents | 20 |
| Section Foremen | 19 |
| Telegraphers | 18 |
| Laborers | 17 |
| Station Helpers | 15 |
| Office Clerks | 11 |

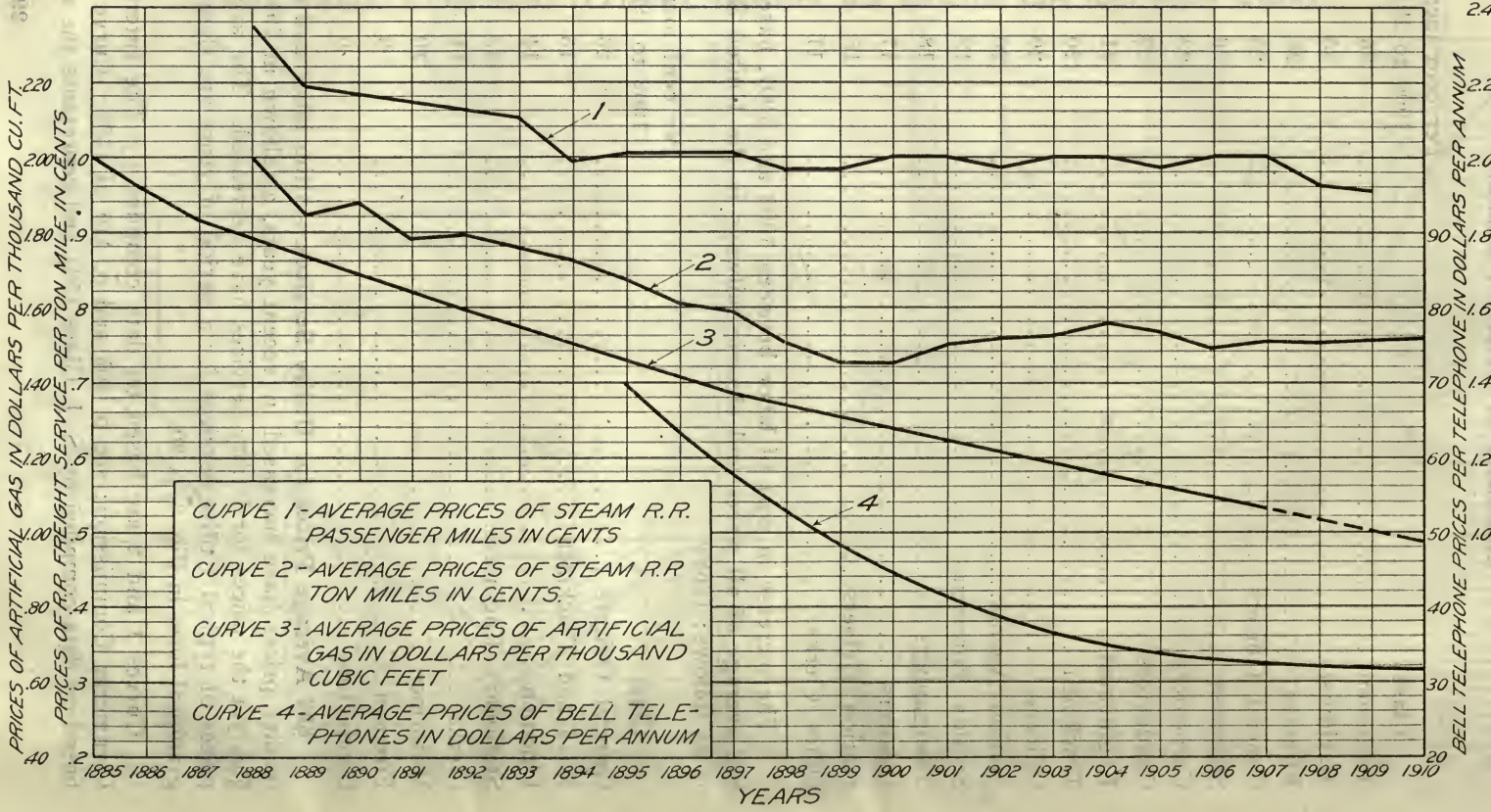
The increase in cost of labor between 1902 and 1907, based on the average of all street and electric railways in the United States is as follows: (268)

| Class | Per cent increase 1902 to 1907 |
|---|---|
| General Officers | 26 |
| Road and Trackmen | 15 |
| Linemen | 14 |
| Stationary Engineers | 13 |
| Clerks | 11 |
| Motormen | 10 |
| Firemen | 9 |
| Conductors | 6 |

**§99 Average Prices for Utility Services.**—Altho labor and commodity prices have increased in recent years, as shown in §97 and §98, yet the prices for Utility services have decreased. The average prices of typical Utility services for a period of years are shown in graphical form in Fig. 3, p. 30.

Curves 1 and 2 are based on data compiled by The Interstate Commerce Commission: see p. 405 and p. 410 of (59). Curve 3 is based on data compiled by S. J. Glass (52) and represents the aver-

# FIG. 3
## AVERAGE PRICES FOR UTILITY SERVICES


PRICES OF ARTIFICIAL GAS IN DOLLARS PER THOUSAND CU. FT.
PRICES OF R.R. FREIGHT SERVICE PER TON MILE IN CENTS
BELL TELEPHONE PRICES PER TELEPHONE IN DOLLARS PER ANNUM
PRICES OF R.R PASSENGER SERVICE PER PASSENGER MILE IN CENTS
YEARS
1885 1886 1887 1888 1889 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910
CURVE 1 - AVERAGE PRICES OF STEAM R.R. PASSENGER MILES IN CENTS
CURVE 2 - AVERAGE PRICES OF STEAM R.R TON MILES IN CENTS.
CURVE 3 - AVERAGE PRICES OF ARTIFICIAL GAS IN DOLLARS PER THOUSAND CUBIC FEET
CURVE 4 - AVERAGE PRICES OF BELL TELEPHONES IN DOLLARS PER ANNUM
1
2
3
4

age of 100 typical American cities. Curve 4 is the average annual cost of Bell telephones per instrument, excluding toll business. (4)

Street railway fares have remained practically constant on the convenient five-cent basis. However, the carrying limits have been increased at least twelve-fold. Thus, the average distance carried for five cents in 1870 was one mile, while in 1910 it was twelve miles.

For the reasons stated in §3, §144 and §162, natural gas service prices must be increased in the future.

Electric service rates have had a two-fold reduction; first, the rate per K. W. hour has been lowered; second, high efficiency incandescent lamps produce more candle power hours per K. W. hour of current used. The following is based on the rates at Chicago, Ill., but represents average reductions under similar conditions:

| Year | Number of candle power hours purchased for $1.00 worth of electric current |
|---|---|
| 1886 | 1115 |
| 1898 | 2160 |
| 1905 | 2480 |
| 1906 | 3430 |
| 1907 | 4350 |
| 1908 | 5000 |
| 1909 | 7700 |
| 1911 | 8550 |
| 1912 | 9903 |

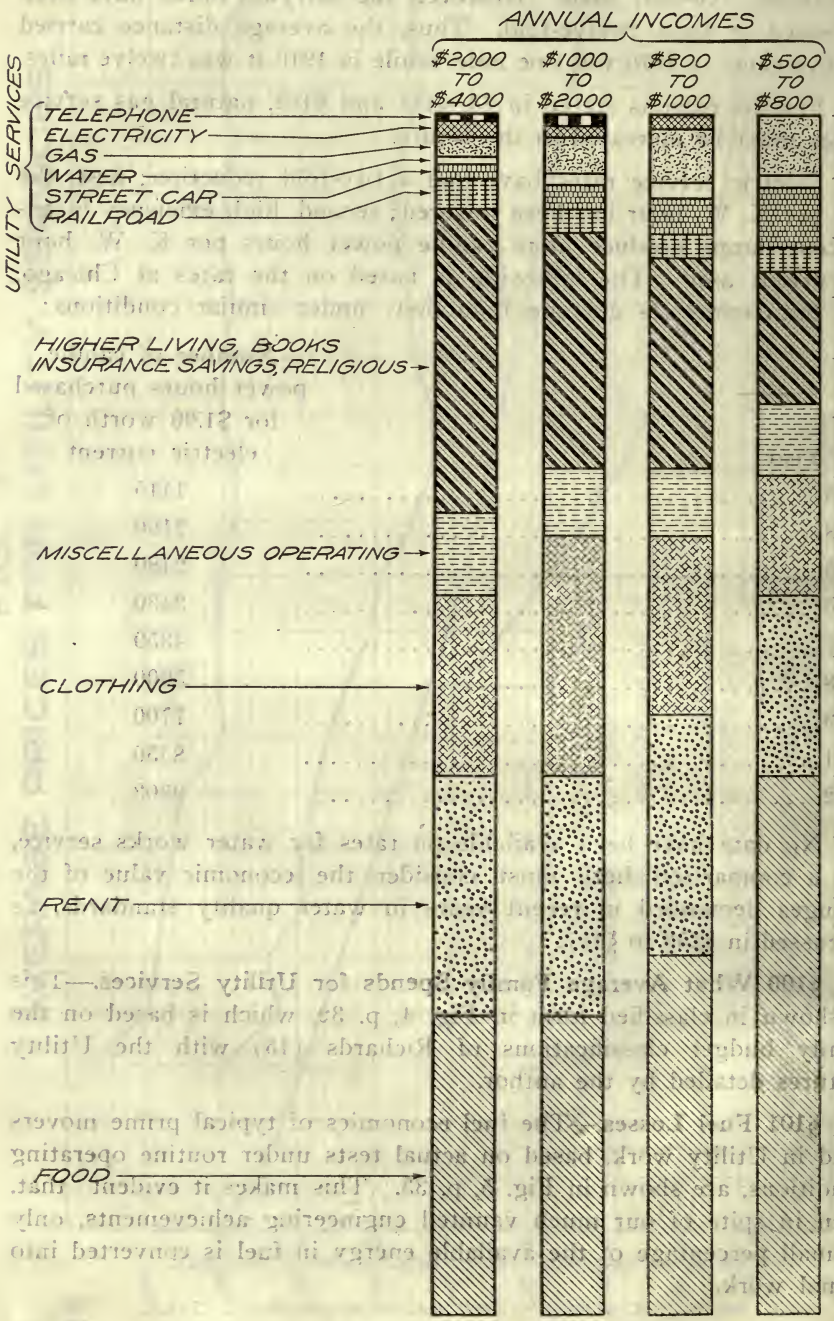
No data have been available on rates for water works service, but a comparison here must consider the economic value of the changes demanded in recent years in water quality standards, as discussed in §153 to §157.

**§100 What Average Family Spends for Utility Services.**—This is shown in classified form in Fig. 4, p. 32, which is based on the family budget classifications of Richards (15) with the Utility features detailed by the author.

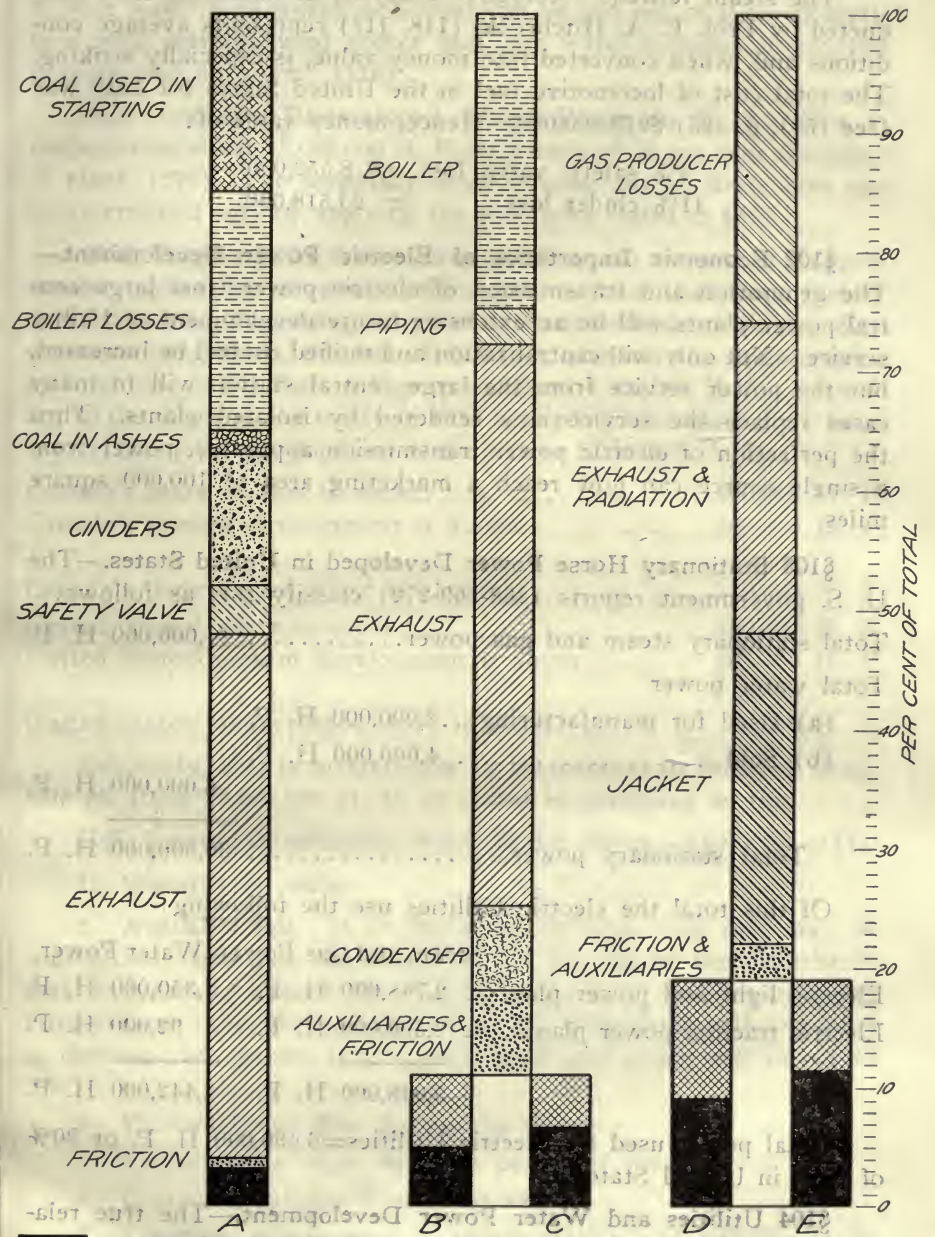
**§101 Fuel Losses.**—The fuel economies of typical prime movers used in Utility work, based on actual tests under routine operating conditions, are shown in Fig. 5, p. 33. This makes it evident that, even in spite of our much vaunted engineering achievements, only a small percentage of the available energy in fuel is converted into actual work.

# FIG. 4

## PERCENTAGE OF DIFFERENT FAMILY ANNUAL INCOMES SPENT FOR UTILITY SERVICES



# FIG. 5
# TYPICAL FUEL ECONOMIES




PERCENT OF TOTAL ENERGY CONVERTED INTO ACTUAL WORK

ELECTRICAL GENERATION, TRANSFORMATION AND TRANSMISSION LOSSES

A - STEAM R.R. LOCOMOTIVE

B - STEAM POWER PLANT DRIVING 600 VOLT DIRECT CURRENT ELECTRIC TRACTION LINE

C - " " " 6600 " ALTERNATING " " LOCOMOTIVE

D - PRODUCER GAS P'R " " 600 " DIRECT " " TRACTION LINE

E - " " " " " 6600 " ALTERNATING " " LOCOMOTIVE

The steam railroad locomotive analysis, as based on tests conducted by Prof. E. A. Hitchcock, (118, 119) represents average conditions and, when converted into money value, is especially striking. The total cost of locomotive fuel in the United States for 1910 was (see (59), p. 425) $213,800.000. Hence, money value of:

4% safety valve loss = $ 8,552,000
11% cinder loss = 23,518,000

**§102 Economic Importance of Electric Power Development.**—The generation and transmission of electric power from large central power plants will be an extensive future development of Utility service. Not only will centralization and unified control be increased, but the power service from the large central station will in many cases replace the service now rendered by isolated plants. Thru the perfection of electric power transmission apparatus, power from a single source can now reach a marketing area of 100,000 square miles.

**§103 Stationary Horse Power Developed in United States.**—The U. S. government reports (268-269-272) classify this as follows:

Total stationary steam and gas power..... 24,000,000 H. P.

Total water power

(a) Used for manufacturing...2,000,000 H. P.

(b) Sold .....4,000,000 H. P.

6,000,000 H. P.

Total stationary power..... 30,000,000 H. P.

Of this total the electric Utilities use the following:

| | Steam and Gas Power | Water Power |
|---|---|---|
| Electric light and power plants | 2,748,000 H. P. | 1,350,000 H. P. |
| Electric traction power plants | 2,300,000 H. P. | 92,000 H. P. |
| | 5,048,000 H. P. | 1,442,000 H. P. |

Total power used by Electric Utilities=6,490,000 H. P. or 20% of total in United States.

**§104 Utilities and Water Power Development.**—The true relation of the various Utilities to existing and undeveloped water powers is little understood and the economic importance of water power development is often exaggerated. The fact that the fuel cost of the various Utilities is relatively only a small part of the total operating cost, as shown in Fig. 11, p. 46, is also little appreciated.

"A water privilege is no longer the pivotal element in business it once was. It is worth just what can be got out of it in competition with manufactured power and city water supplies in favored regions, and no more." (116)

**§105 Available Undeveloped Water Power in U. S.**—This is estimated at about 25,000,000 H. P. on a basis of 70 per cent efficiency of plant. (272) The feasibility of developing any of these sites can be ascertained only by applying the principles stated in §107.

**§106 Niagara Falls Water Power** (272).—On account of its spectacular nature, the economic importance of this has been greatly overestimated. According to careful measurements made by governmental engineers, the fall of 215 feet between the upper rapids and the base of the Falls will generate about 4,000,000 H. P. According to the terms of the treaty of 1910 between Canada and the United States, the joint development is limited to 1,000,000 H. P.

| | |
|---|---|
| Canada's share of this is about | 640,000 H. P. |
| Canada's present development is about | 500,000 H. P. |
| Canada's undeveloped share is about | 140,000 H. P. |
| United States' share is about | 360,000 H. P. |
| United States' present development is about | 263,000 H. P. |
| United States' undeveloped share is about | 97,000 H. P. |

Relatively, this is insignificant in comparison to the total available H. P. of 25,000,000 H. P. as stated in preceding section.

**§107 Factors Determining Water Power Value.**—These are (114):

1. Quantity of water.
2. Available fall. It is important to note that this may be considerably less than the actual fall on account of the disturbance that is generally caused by "high" and "low" water conditions. Furthermore, other things being equal, the lower head will cost more to develop and operate than a high head, and hence will be worth less.
3. Uniformity of flow during the year.
4. Uniformity of flow during a period of years.
5. Cost of equalizing flow by storage.
6. Location, with regard to transportation and building facilities.
7. Cost of manufactured power to compete with water power.
8. Cost of manufactured power to supplement water power plant during low water period.

9. Market for power.

10. Water needed for purposes other than power.

**§108 Limiting Value of Ample Water Power.**—"The value of water power, when of ample capacity for a specific purpose, does not exceed the cost of what a competing manufactured power (steam, oil engine, gas engine or transmitted electric energy) can be installed and operated for at the same locality." (116)

**§109 Value of Insufficient Water Power.**—"When a water power is insufficient for a specific purpose, due to varying flow at different seasons of the year and its limited amount, then its value is reduced from that established by §108, by the cost of installing and operating manufactured power to make good this insufficiency." (116)

**§110 Saving Affected by Water Power** (116).—The difference between the sum of the fixed and running costs of manufactured power and the sum of the fixed and running costs of water power, both delivered to the same place, represents the annual saving effected by the water power.

**§111 Present Worth of Undeveloped Water Powers** (134).—Some water powers, so located that their present development would not be profitable, may have a value as holdings for future use. The present cash value of such a speculative power is the present worth—at a high capitalization rate on account of the risks involved—of the sum for which it could be sold at some future time when, according to a reasonable prognostic of industrial progress in the locality, it will become marketable.

"The same method may be applied to the case of determining the value of an inferior water power in a region where the market is controlled by some form of power that is at present cheap, but which may in time become exhausted." (134)

**§112 Units Used for Measuring Utility Service.—**

Water—cubic foot or gallon.
Gas—1000 cu. ft., abbreviated "M."
Electricity—1000 watts or kilowatt, abbreviated K. W.
Passenger transportation—passenger mile.
Freight transportation—ton mile.
Telephone—time and number of calls.
Telegraph—number of words.
Heating—square feet radiation or quantity of steam condensed.

**§113 Relative Heat Unit and Candle Power Hour Costs.**—These are shown in Fig. 6, p. 37. For definition of heat unit see §692, and of candle power hour see §634.

# FIG. 6
# RELATIVE HEAT UNIT AND CANDLE POWER HOUR COSTS

| | NAME | GROSS HEAT UNITS PER UNIT | PRICE PER UNIT | WHAT ONE DOLLAR WILL BUY | | | |
|---|---|---|---|---|---|---|---|
| | | | | NUMBER HEAT UNITS | NUMBER CANDLE POWER HOURS SERVICE | HOT AIR FURNACE HEATING SERVICE | |
| | | | | | | PERCENTAGE OF HEAT UNITS IN FUEL ACTUALLY UTILIZED BASED ON TESTS | NUMBER HEAT UNITS AVAILABLE IN HEATED AIR |
| PURCHASED AS A COMMODITY | ANTHRACITE COAL | 14000 PER LB. | $10.00 PER TON | 2800000 | | COAL FURNACE 20% | 560000 |
| | SEMI-ANTHRACITE COAL | 13500 " " | $6.00 " " | 4500000 | | | 900000 |
| | BITUMINOUS COAL | 12500 " " | $4.00 " " | 6250000 | | | 1250000 |
| | CRUDE OIL | 152000 PER GAL | 3¢ PER GAL. | 5066600 | | | |
| | KEROSENE | 124000 " " | 12¢ " " | 1033000 | OIL LAMP 5350 | | |
| | GASOLINE | 118000 " " | 18¢ " " | 655500 | GASOLINE LAMP-13000 | | |
| | DENATURED ALCOHOL | 73000 " " | 40¢ " " | 182500 | | | |
| | ACETYLENE | 1400 PER CU.FT. | 4¢ LB. CARBIDE | 140000 | ACETYLENE BURNER-5000 | | |
| PURCHASED AS A SERVICE | NATURAL GAS | 1000 " " | 50¢ PER 1000 CU.FT. | 2000000 | WELSBACH BURNER-26400 | GAS BURNER IN COAL FURNACE 30%<br>GAS FURNACE 62% | 600000<br>1240000 |
| | ARTIFICIAL GASES — OIL GAS | 640 " " | $1.00 " " | 640000 | FLAT FLAME BURNER-5000<br>WELSBACH BURNER - 13000 | | |
| | ARTIFICIAL GASES — RETORT COAL GAS | 640 " " | $1.00 " " | 640000 | FLAT FLAME BURNER - 5000<br>WELSBACH BURNER - 13000 | | |
| | ARTIFICIAL GASES — GASOLINE GAS | 625 " " | $1.00 " " | 625000 | FLAT FLAME BURNER - 5000<br>WELSBACH BURNER - 13000 | | |
| | ARTIFICIAL GASES — COKE OVEN GAS | 600 " " | $1.00 " " | 600000 | FLAT FLAME BURNER-5000<br>WELSBACH BURNER - 13000 | | |
| | ARTIFICIAL GASES — CARBURETED WATER GAS | 600 " " | $1.00 " " | 600000 | FLAT FLAME BURNER-5000<br>WELSBACH BURNER-13000 | | |
| | ELECTRICITY | 3412 PER K.W. | 5¢ PER K.W. HR. | 68200 | CARBON LAMP 6000<br>TUNGSTEN LAMP 16000 | | |

**§114 Taxation of Utilities.**—All Utility property must be taxed equitably. Hence, the property of a Utility must be taxed on exactly the same basis that private property is taxed in the same locality. If private property is taxed for 50% of its fair value, then the Utility must be treated likewise. On the other hand, if private property is assessed at its full value—which is the only fair basis—then the Utility property should be assessed on a similar basis.

Any rate regulation which does not provide for equitable taxation is unjust to the community at large.

**§115 Excise Taxes Are a Burden On the Consumer.**—In computing the cost of Utility service, it is self-evident from Figs. 41, p. 187, and 42, p. 188, that any taxes on output earnings or franchises merely increase the price which the consumer must pay for the service. Hence, the federal, state and municipal excise taxes do not tax the Utility, but place the burden directly on the users of Utility service.

This was clearly defined by a court in affirming the right of the Utility to add the excise tax to the cost of its service. "The duty is laid upon the consumer and not upon the Utility; but it is collected from the Utility merely for reasons of economy." (581)

"Whatever a municipality secures from a Utility for a franchise may be added to the charge for service. If the payment is made annually in either money or service, the Utility may recoup itself directly from its customers in that year.

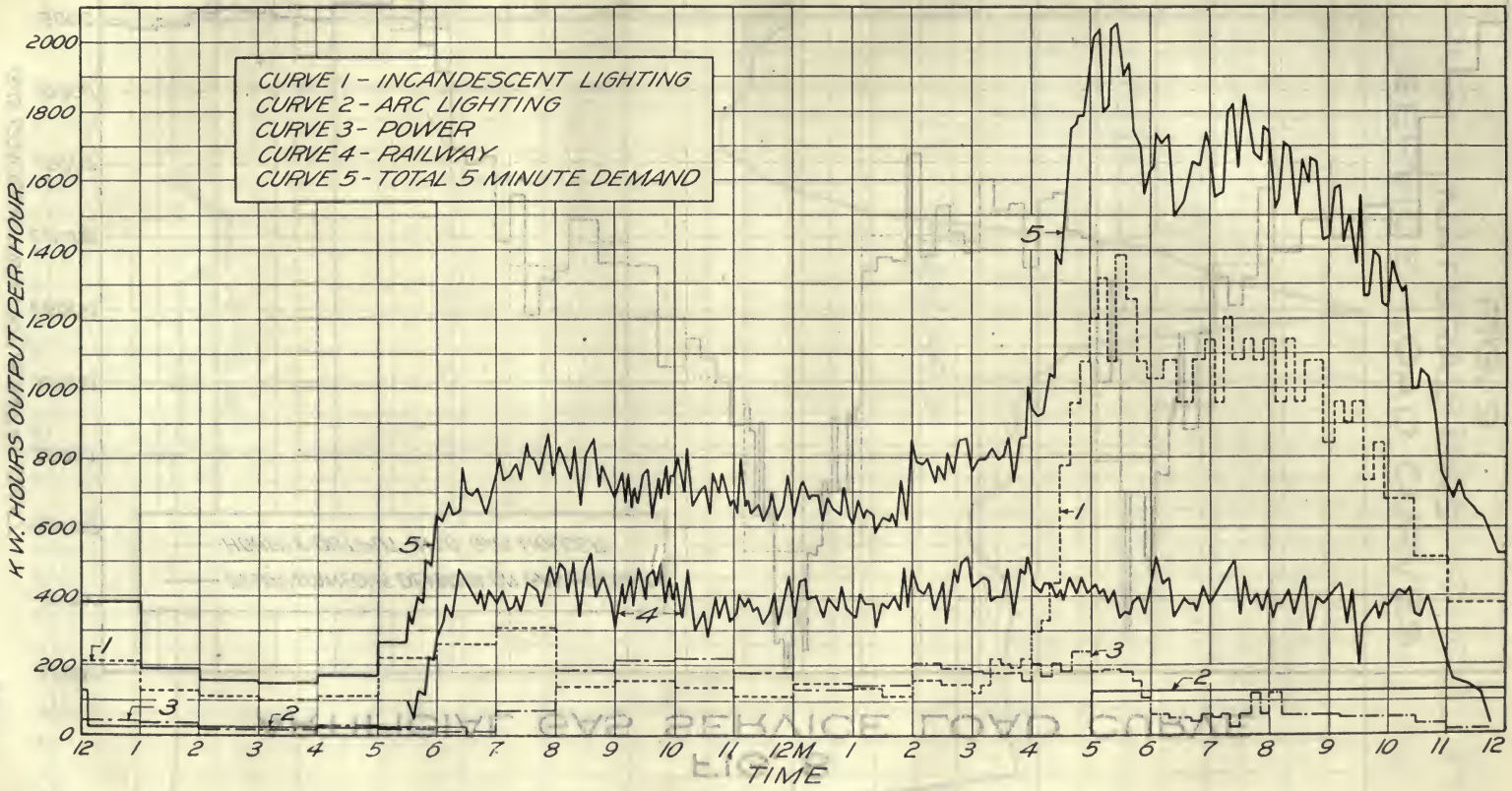
If the payment is made in a lump sum at the time of granting the franchise, the amount paid must be spread over all the bills for the entire term of the franchise. This can be done only by issuing stock or bonds to the persons advancing the money paid and making annual return to them by way of dividend or interest." (687)

**§116 Load Factor.**—The percentage that the actual output is of the possible total plant output is the load factor. Thus a 40% load factor means that 60% of the possible total plant output is not utilized.

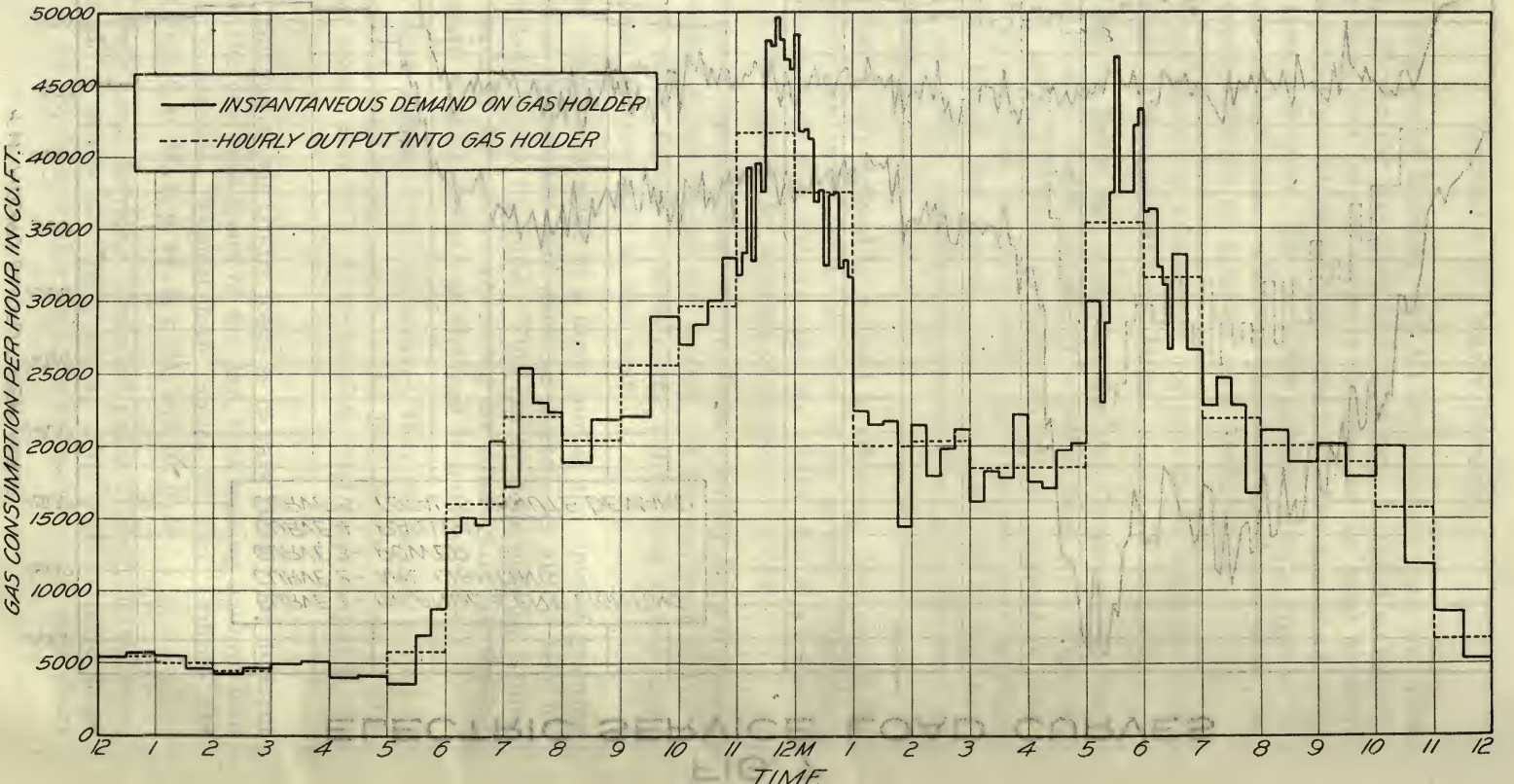
The tendency of all Utility loads is to vary largely for different seasons of the year and hours of the day, thus making uniform load conditions impossible. Typical load curves of four Utilities are shown in Figs. 7, p. 39; 8, p. 40; 9, p. 41, and 10, p. 42.

**§117 Peak Load Service.**—Abnormal peaks of short duration are characteristic of nearly all Utility loads. This necessitates a large investment for equipment that is actually used only a very short

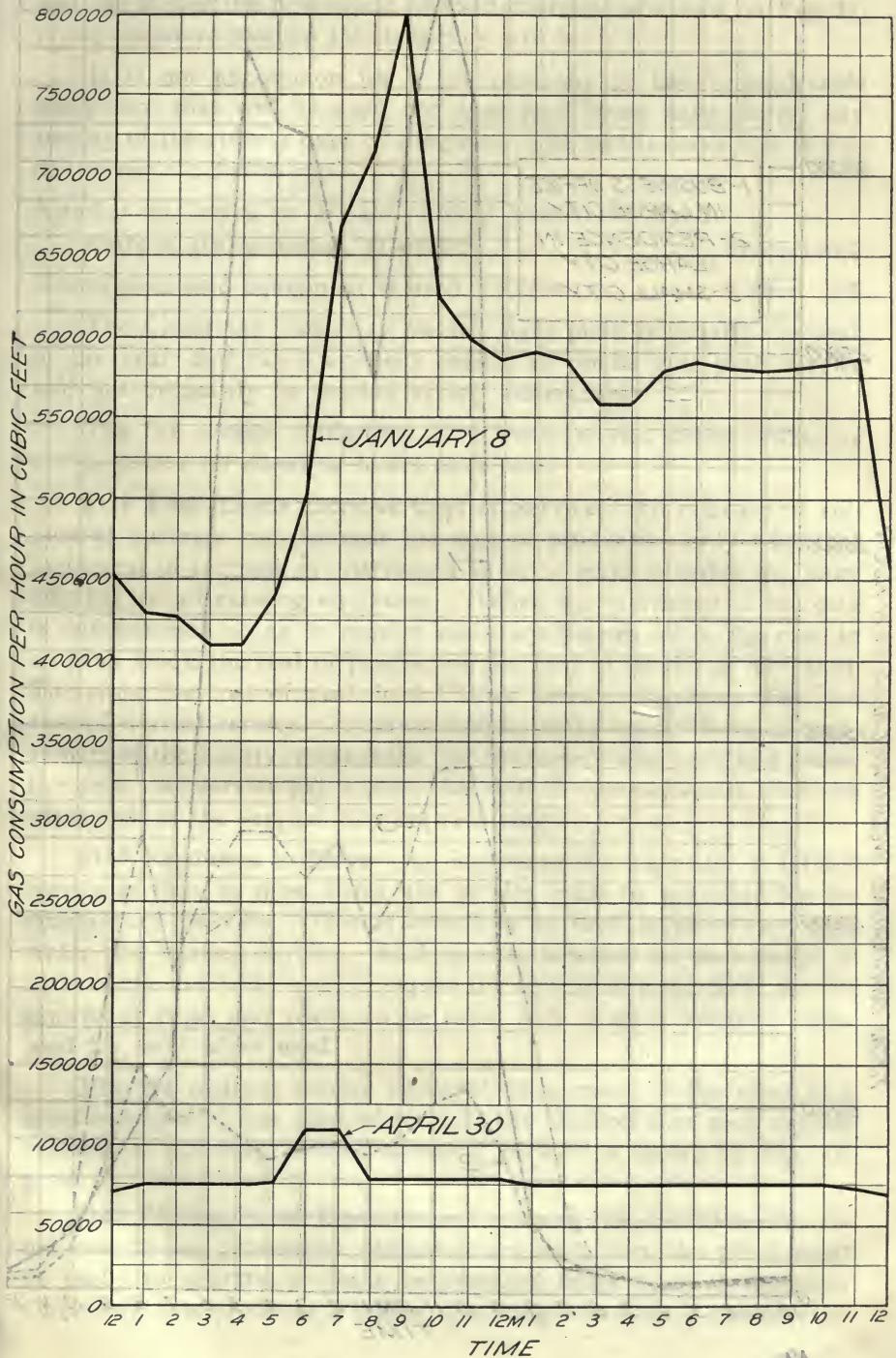
# FIG. 7
# ELECTRIC SERVICE LOAD CURVES



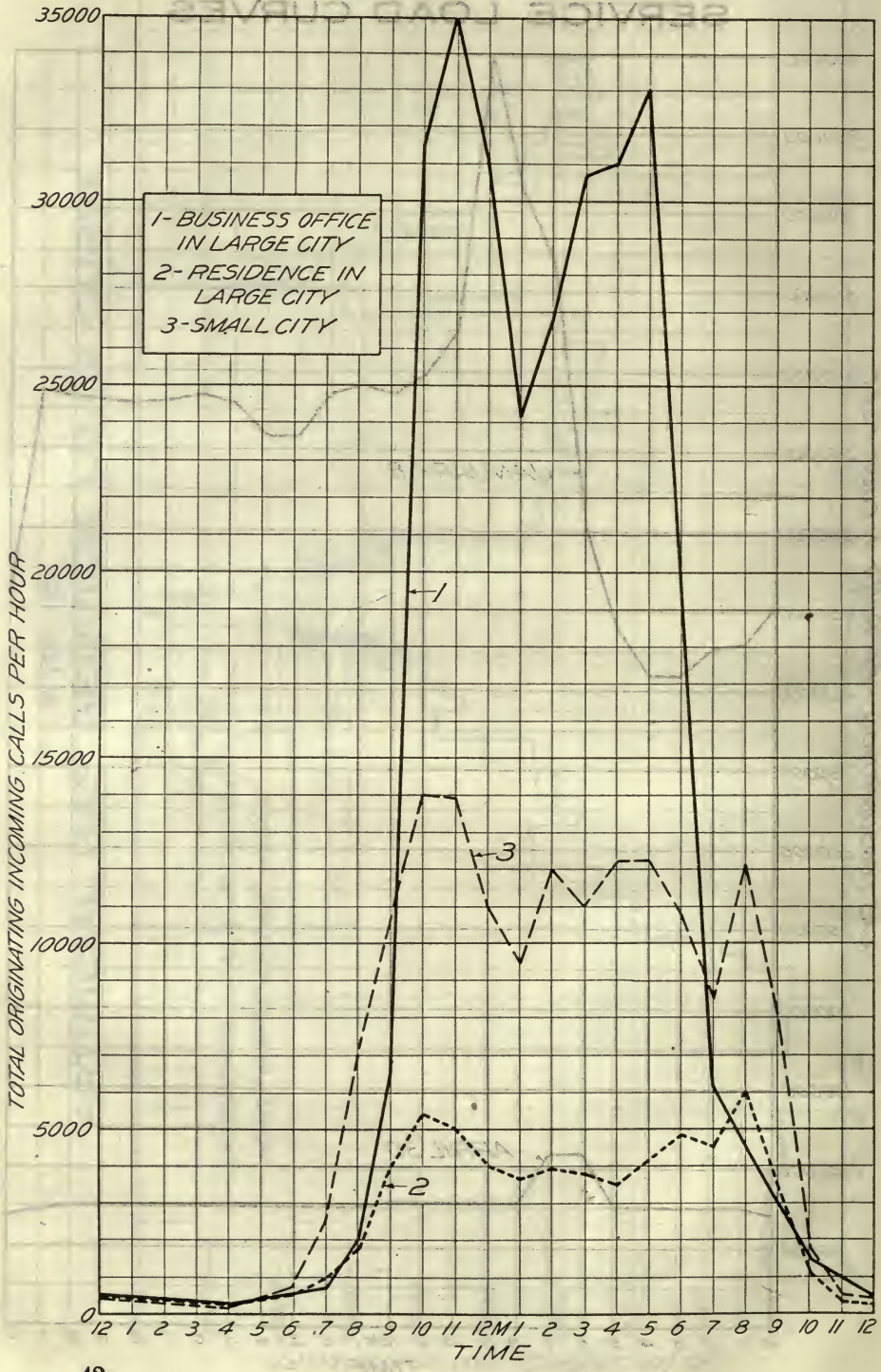
# FIG. 8
# ARTIFICIAL GAS SERVICE LOAD CURVE



# FIG. 9
# NATURAL GAS SERVICE LOAD CURVES



# FIG. 10
# TELEPHONE SERVICE LOAD CURVES



period out of each year. This increases the fixed charge burden, and the higher the proportion of fixed charges, as shown on Fig. 11, p. 46, the more marked this tendency will be.

It is not uncommon for a gas company to have considerable equipment that will be used not over four hours daily during say twenty of the coldest days of the year. The smallness of this is evident from the following:

Number of hours in a year during which the fixed charges are accruing, $24 \times 365 = \ldots\ldots\ldots\ldots\ldots\ldots 8760 = 100\%$

Hours peak load equipment is used, $4 \times 20 = \ldots\ldots\ldots\ldots\ldots 80 = 1\%$

The Christmas load of an electric light plant is usually the peak of the year, and the equipment needed to render this peak service will not ordinarily be needed at any other time.

The fire service equipment of a water works would ordinarily not be used over about 20 hours each year.

**§118 Peak Loads Increase Cost of Service.**—An increase of volume of business can decrease the cost of production only when the increment of increase is distributed so as to make possible the more efficient use of existing equipment. When the increment of increase is concentrated so as to require more equipment, as is the case in all peak loads, the cost of production per unit of service is increased. Therefore the cost of peak load Utility service is greater than the cost of normal service. A rate schedule, to be equitable to all consumers of the Utility, must make the consumers who need and create the peak load service pay a price that will be commensurate with the extra cost of the service they are receiving.

**§119 Readiness to Serve.**—An important characteristic of Utility service is that, in most cases, the service must be available for instantaneous delivery. This is especially marked in electricity, gas, water and heating service. Each patron, whether he uses much or little of the available service, enjoys the benefit of a potential service always at hand and ready to be used, and, if on a metered basis, paid for only when used.

The fire hydrant service rendered by a water works plant is a good example of this class of service; the relation that such service sustains to ordinary routine domestic service is shown in Fig. 14, p. 54.

**§120 Continuity of Operation.**—In nearly all Utilities, the requirements for continuous operation are such that the plant must be ready to operate, or must be operated every hour of the year. Obviously, this produces a higher operating cost than if the require-

ments for readiness to serve were not universally necessary. Furthermore, transportation Utilities, which are usually highly susceptible to depressed financial conditions, must be kept going, regardless of the inadequate income produced.

**§121 Service and Commodity.**—The primary object of all Utilities is to render a service, rather than furnish a commodity. Even with gas, electricity or water Utilities, to value the gas, electricity or water merely as a commodity is fundamentally wrong.

The distinction between rendering a service and manufacturing a commodity is an important one. The commodity may be manufactured at a uniform rate of production and then be placed in storage until it can be sold to advantage. A service must be used at the moment it is offered or it will become forever useless. The load factor data in §116 emphasizes the erratic nature of Utility loads and the potential opportunities for rendering service that are never used.

**§122 Storage.**—Telephone and telegraph Utilities have no storage other than that accruing from letting messages take their turn for transmission, but since expedition is the primary requirement for regular business, such a storage feature cannot be considered. However, the recently installed "day letter" and "night letter" telegraph service logically comes under the storage condition and tends to produce a more uniform use of the lines.

Transportation Utilities handling imperishable commodities may equalize their loads by storing or holding along the line, but this is impossible in the case of perishable commodities.

Passenger Utilities have no storage, and must adapt their carrying capacity to the fluctuating number to be carried.

Water and gas Utilities may have storage, so far as the compressing or generating plant is concerned. However, their distributing systems must be able to handle all peak loads without equalization, including the water fire service called for in §152. The only feasible storage in water Utilities is an elevated reservoir, and in gas Utilities a gas holder or long, high-pressure transmission line. The gas storage capacity of various sized mains is discussed in §683 and shown in Fig. 47, p. 251.

Heating and sewerage Utilities can have no storage.

The only way that electricity may be stored is in the electric storage battery, and the commercial limitations of this are such as to make it of no consequence. Hence, in general, Electric Utilities have no commercial feasible storage.

**§123 Overload.**—Telephone and Telegraph Utilities have no overload; in intelligence communication the message during the time of its transmission occupies the line to the exclusion of all else.

Practically all other Utilities have overload margins. However, a plant carrying an overload is soon likely to render inferior or inadequate service.

**§124 Fixed and Variable Cost Relation.**—These terms are defined in §50 and §51, and their average relation in six typical Utilities is shown in Fig. 11, p. 46. Their effects on electric power rates, for instance, is shown in Fig. 12, p. 47.

**§125 Mobility of Capital.**—"Capital is a peculiarly mobile commodity. Capital will flow from one part of the world to another in accordance with the inducements which are offered it. Capital will leave any given field with great speed if it finds that it is receiving unfair or unjust recompense or if other fields offer greater inducements. Without capital, modern enterprise is impossible." (99)

**§126 Economic Importance of Capitalist.**—"No new industry can be established or, when established, can continue to grow without the continued presence of the individual who supplies the financial resource to the engineer. We should give to the promoter, to the capitalist, to the man who is able to influence capital, the credit that is properly due him. If a brief and unprejudiced study is made of the history of the earlier Utilities, it will be impossible to depart from the conviction that the persistence and courage of the promoter and capitalist who carried them thru their earlier periods of disaster and lack of credit are quite as notable as the work of the engineers who produced the physical and scientific part of these enterprises." (99)

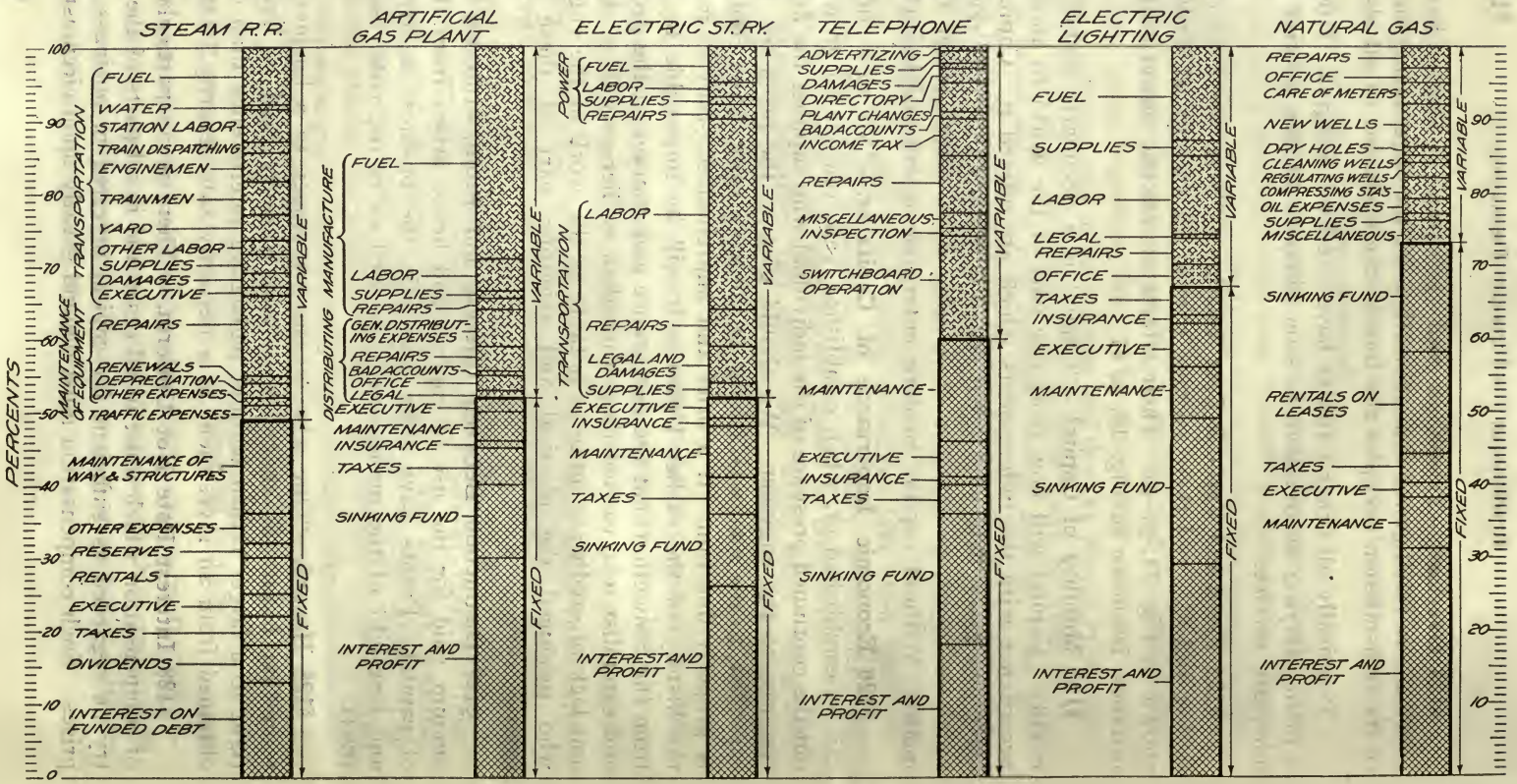
**§127 Distinction Between Interest and Profit.**—Interest is the amount paid for the use of capital, and hence arises from the use of capital. Profits have their source in the business ability, skill and foresight of the management, as well as in the risks assumed. (693)

**§128 Hazard.**—"One who invests his money in a business of a somewhat hazardous character is very properly held to have the right to a larger return without legislative interference than can be obtained from an investment in a perfectly safe security." (489)

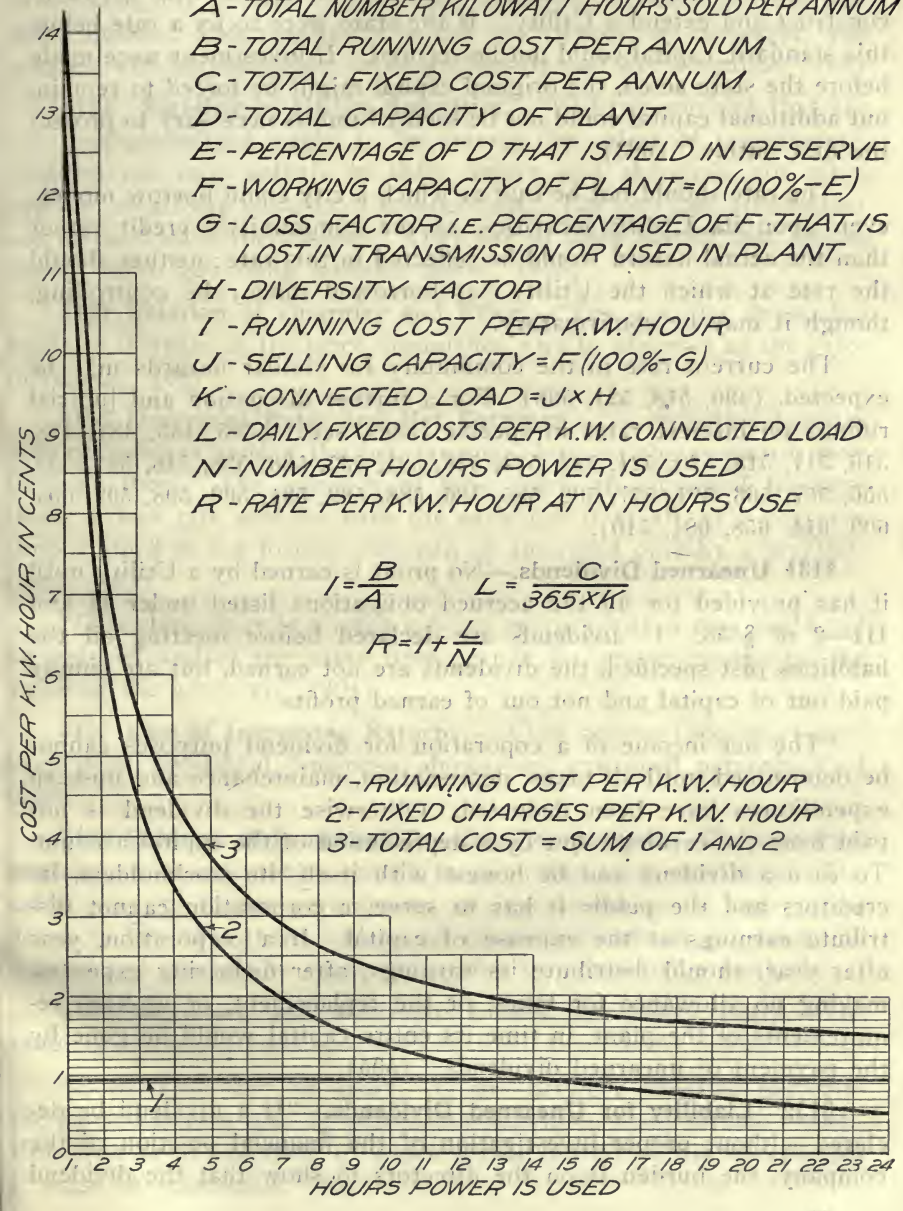
**§129 Interest Rate Not Uniform.**—"There is no particular rate of compensation which must in all cases and in all parts of the country be regarded as sufficient for capital invested in business enterprises. Such compensation must depend greatly upon circumstances,

# FIG. 11

# CLASSIFICATION OF FIXED AND VARIABLE CHARGES IN PERCENTAGE OF TOTAL OPERATING COST



# FIG. 12
# CURVES SHOWING RELATION OF COST AND NUMBER HOURS USE OF ELECTRIC POWER


A - TOTAL NUMBER KILOWATT HOURS SOLD PER ANNUM
B - TOTAL RUNNING COST PER ANNUM
C - TOTAL FIXED COST PER ANNUM
D - TOTAL CAPACITY OF PLANT
E - PERCENTAGE OF D THAT IS HELD IN RESERVE
F - WORKING CAPACITY OF PLANT = D(100% - E)
G - LOSS FACTOR I.E. PERCENTAGE OF F THAT IS LOST IN TRANSMISSION OR USED IN PLANT
H - DIVERSITY FACTOR
I - RUNNING COST PER K.W. HOUR
J - SELLING CAPACITY = F(100% - G)
K - CONNECTED LOAD = J x H
L - DAILY FIXED COSTS PER K.W. CONNECTED LOAD
N - NUMBER HOURS POWER IS USED
R - RATE PER K.W. HOUR AT N HOURS USE
$I = \frac{B}{A}$ $L = \frac{C}{365 \times K}$
$R = I + \frac{L}{N}$
1 - RUNNING COST PER K.W. HOUR
2 - FIXED CHARGES PER K.W. HOUR
3 - TOTAL COST = SUM OF 1 AND 2
COST PER K.W. HOUR IN CENTS
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
HOURS POWER IS USED

locality, amount of risk in the business and rate upon investments of a somewhat similar nature with regard to the risk attending them." (488)

**§130 Specific Rate of Return.**—"Various standards have been suggested for determining the fair rate of return. The one which in our opinion is properly applicable is that the rate should be such that investors would be induced to provide the funds with which to construct and extend a Utility. If the state were to fix a rate below this standard, capital could not be secured. If investment were made before the state acted, the original capital might be forced to remain, but additional capital could not be secured unless necessary to protect the first outlay." (683)

The rate should not be that at which a city could borrow money, even upon its Utility securities, as the community's credit rather than the actual hazard would be reflected in this rate; neither should the rate at which the Utility has borrowed money be controlling, though it may be confirmatory.

The current rate in the community for similar hazards may be expected. (490, 518, 521, 538) For a further discussion and judicial rulings on interest rates in specific cases, see: (395, 465, 484, 488, 516, 517, 518, 520, 521, 522, 524, 526, 531, 535, 536, 538, 546, 554, 555, 556, 557, 563, 571, 577, 582, 585, 586, 588, 589, 591, 592, 598, 599, 604, 609, 614, 658, 684, 710).

**§131 Unearned Dividends.**—No profit is earned by a Utility until it has provided for all the accrued obligations listed under II and III—2 of §558. If dividends are declared before meeting all the liabilities just specified, the dividends are not earned, but are simply paid out of capital and not out of earned profits.

"The net income of a coporation for dividend purposes cannot be determined until all taxes, depreciation, maintenance and up-keep expenditures have been deducted. Otherwise the dividend is not paid from the earnings, but by a depreciation of the capital account. To earn a dividend and be honest with itself, its stockholders, its creditors and the public it has to serve, a corporation cannot distribute earnings at the expense of capital. If a corporation, year after year, should distribute its earnings, after deducting expenses, making no allowance for taxes, or the replacement, or up-keep requirements of the plant, in time its entire capital would be gone by the payment of unearned dividends." (595)

**§132 Liability for Unearned Dividends.**—"If a dividend be declared without proper investigation of the financial position of the company, the burden is on the directors to show that the dividend

was properly declared, and in default a director will be ordered to refund the dividend he has received; and if directors pay dividends out of capital, they may be liable for the whole amount so misapplied." (620-621-622-623)

**§133 Direct Interest In Investment Increases Efficiency.**—"The more close and direct the connection between the investor and the investment, the greater will be the economy and efficiency; and the more indirect and remote from the contributor or tax-payer, the greater will be the waste, mismanagement and extravagance." (49)

**§134 Stability of Utility Securities.**—"Utility securities that are not over-capitalized ought to be among the safest of investments. Utilities are monopolistic in their nature and therefore not often exposed to all the hazards of competition. The services they render are in most cases necessities. They are of such nature that people cannot often get along without them." (693)

**§135 Relation of Quantity and Price.**—"The quantity demanded tends to increase as the price diminishes, and to diminish as the price increases." (22)

**§136 Decreased Rates and Net Earnings.**—"A reduction in rates will not always reduce the net earnings, but, on the contrary, may increase them. The question of how much an increased business under a less rate will increase the earnings, if at all, at a cost not proportioned to the former cost, can be answered only by a practical test." (491)

"Of course there is always a point below which a rate could not be reduced and at the same time permit the proper return on the value of the property." (491)

**§137 Law of Increasing Returns.**—When constant expenses have been paid, additional business shows an enhanced percentage of profit.

**§138 Relation of Profit and Possible Competition.**—The universal tendency is to attempt to punish large profits by competition. The safest way to insure permanency of investment is to keep prices down so low that there will be no undue inducement for others to step in and attempt to share the profits by competitive methods.

**§139 Maximum and Minimum Limits for Utility Rates.**—The range of Utility rates is restricted between two clearly defined limits.

"Both limits are far apart. Where between the two extremes the particular rate shall be placed depends upon many circumstances. But there is no standard to which a rate must conform except that it must be reasonable." (3)

**§140 Economic Limit of Maximum Utility Rate** (43).—The maximum rate is fixed by what the service is worth to the consumer. This is an economic rather than a legal limitation, because it may be legal to charge more than the service is worth, altho in such case the consumer will not use the service.

"In the last analysis, the Utilities can secure no more for the service than the people will give up to obtain it. What they will give up depends on their desires and their necessities. If the rates exceed the first, the people will give up only so much as satisfies their necessities and the traffic will be enormously reduced." (179)

A charge for any Utility service cannot exceed the value added by that service. No man will pay more for any service than it is worth to him. The maximum rate, therefore, is fixed by what the consumer can afford to pay.

**§141 Economic Limit of Minimum Utility Rate** (3-43).—The minimum rate is fixed by the cost of the service to the Utility. This is both a legal and an economic limitation because the Utility should not furnish its service below cost, and cannot properly be required to do so.

A charge for any Utility service cannot go below the expense which would not have been incurred had the service not been rendered. A rate cannot be made lower than the additional cost of rendering the particular service. The extra outlay must be compensated for or the Utility will lose by rendering the service. The minimum rate, therefore, is fixed by what the Utility can afford to render the service for.

**§142 Relation of Location and Price.**—The highest prices for commodities and men's services are obtained when they can move quickly to any point where demand may arise. The value of the service rendered in moving commodities and men from one place to another is the increase in value of the commodities or men's services due to change of location. Hence, the value of the service rendered to the commodities or men is of much more importance than commodity cost, or cost of service to the Utility.

**§143 Creation of Value by Transportation.**—"When commodities have a market value in one locality greater than in another, the value to the shipper of transporting them from the one place to the other is the difference in price. Transportation creates value to the extent of the difference. A charge, however, which is greater than the value created will stop shipments. Traffic cannot be charged beyond its ability to pay. If it is, it will not move." (3)

**§144 Creation of Value by Transmission of Energy.**—The principle of the preceding section applies to the creation of value in oil, natural gas, electricity or other forms of energy, by performing a service in transmitting these from a place of low market value to one of higher market value. The increment of market value increase represents the maximum value of the transmitting service.

The large number of steps necessary to transmit natural gas from the gas field to the gas consumer is shown in Fig. 13, p. 52. This naturally also suggests the large fixed investment necessary to make possible the rendering of such service, and without this the gas in the field is almost valueless. The transmission service is therefore a vital factor in determining the cost of the gas service to the consumer.

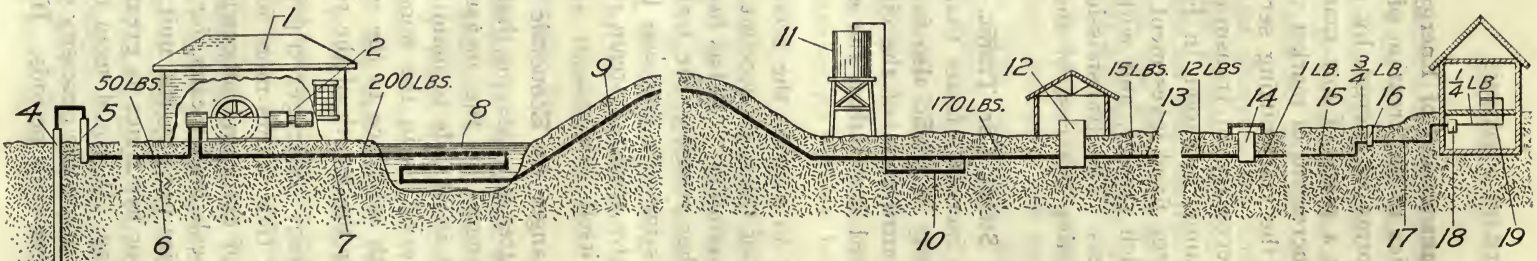
**§145 Population Increase and Street Car Traffic.**—"As a city grows, the number of rides always increases faster than population. The accompanying increase in density of traffic also favors economical service; and the per capita contribution of the citizens to the support of the railway has increased faster than the extent of the latter's permanent plant." (248)

No general rules can be given to express the accurate relation of population increase and number of rides, on account of the many factors that are peculiar to each community. "It has been suggested that, within certain limits and rather roughly, the traffic varies as the square of the population,—the same rule that was laid down by Wellington to estimate the prospective traffic of steam roads." Each case must, however, be studied by itself. (682)

**§146 Is the Street Car Strap-Hanger An Economic Necessity?**—"The easy way to dispose of the matter is to assume that the number and proportion of standing passengers is the measure of overcrowding. But this assumes that it is feasible to maintain the same quality of service in the rush period as in the non-rush period, quality of service being defined with reference to the wishes of the passenger, namely, a seat at will for the length of the ride." (248)

During the rush hour the average passenger trip is longer; in other words, the passenger at that time wants more for his nickel. On the other hand, the providing of extra and otherwise little-used equipment and employes for the peak load means, for the railway company, a greater cost of the service per physical unit at this time. The demand for seats may be four or five times as great at the rush hour as it is in the middle of the day. It would seem that the only way to deal with this situation is to admit the necessity of a different standard of service for rush and non-rush periods. If the rate of

# FIG. 13
# DIAGRAM SHOWING CONNECTIONS BETWEEN NATURAL GAS PRODUCING STRATA AND GAS CONSUMERS FIXTURES




1-GAS COMPRESSING STATION
2-GAS COMPRESSOR
3-GAS PRODUCING STRATA
4-GAS WELL
5-DRIP
6- INTAKE PIPE
7-DISCHARGE PIPE
8-COOLER
9-TRANSMISSION LINE
10-GASOLINE DRIP
11-GASOLINE STORAGE TANK
12-PRESSURE REDUCER
13-HIGH PRESSURE CITY MAIN
14-REGULATOR
15-LOW PRESSURE CITY MAIN
16-SERVICE BOX
17-SERVICE PIPE
18-CONSUMERS GAS METER
19-CONSUMERS HOUSE PIPING

fare is to remain constant, it would seem necessary to allow a company to provide relatively fewer cars for its rush hour than for its non-rush travel." (248)

But for the uniformity of street railway rates, the rush hour passenger might justifiably be charged more than the non-rush passenger. Vice versa, it is not unreasonable that he should, paying the same fare, expect to have to put up with a somewhat less comfortable ride at that time. There is certainly little economic ground for an especially reduced fare for this service.

**§147 Empty Car Return Cost.**—In much of the service rendered by transportation Utilities, the cars are returned empty. The cost of making this return must be added to the actual transportation cost in order to secure the true service cost. This is especially pertinent to the peak load business, since nearly all of this at a particular time is in one direction, and necessitates the return of empty or under-loaded cars.

**§148 Relation of Use and Cost of Service.**—On account of the controlling influence of the fixed charges, the amount of any Utility service used each day has a vital bearing on the cost of rendering such service. The fixed charge burden on each service unit decreases as the number of service units per day is increased. This is shown graphically for electrical power service in Fig. 12, p. 47.

**§149 Complexity of Telephone Service Equipment.**—This is illustrated in Fig. 15, p. 55, which also shows the aerial, interior block and underground cable types of construction; but the calling circuit connecting the two switchboards is not shown.

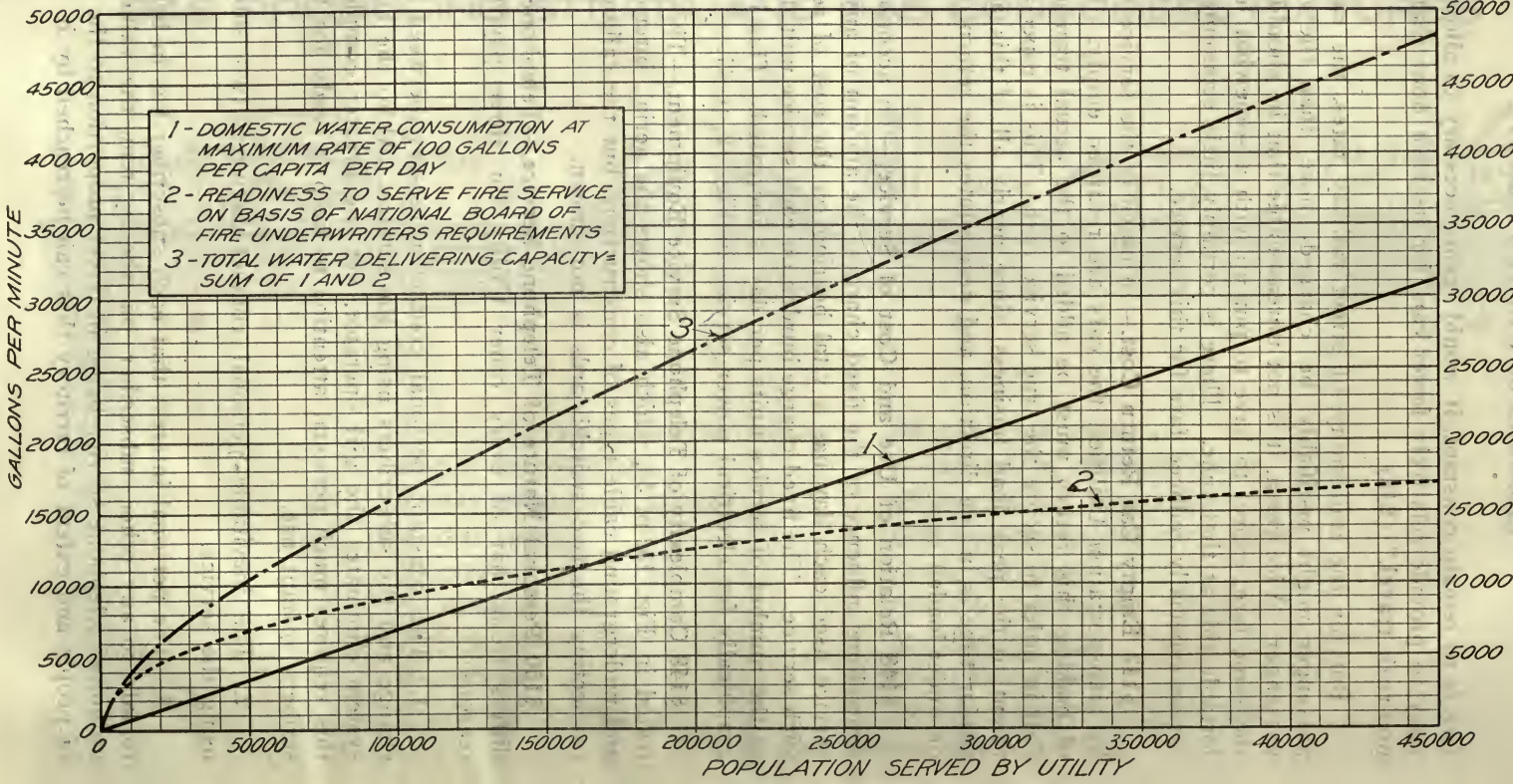
**§150 Personal Nature of Telephone Service.**—Telephone service differs from that of every other Utility for three psychological reasons:

1. The constant personal contact necessary between the exchange and the subscribers using the service. Altho the automatic system eliminates the girl operator, yet the greater complexity of this requires much personal attention to keep it ready for the subscribers' instant use.

2. The inevitable personal contact between two subscribers using the service.

3. The personal interest that each subscriber has in being able to talk to any other subscriber on the system, the value of the unlimited telephone service being in direct proportion to the number of people and extent of territory that can be reached by it. (602)

# FIG. 14
# READINESS TO SERVE FEATURES OF WATER WORKS FIRE SERVICE



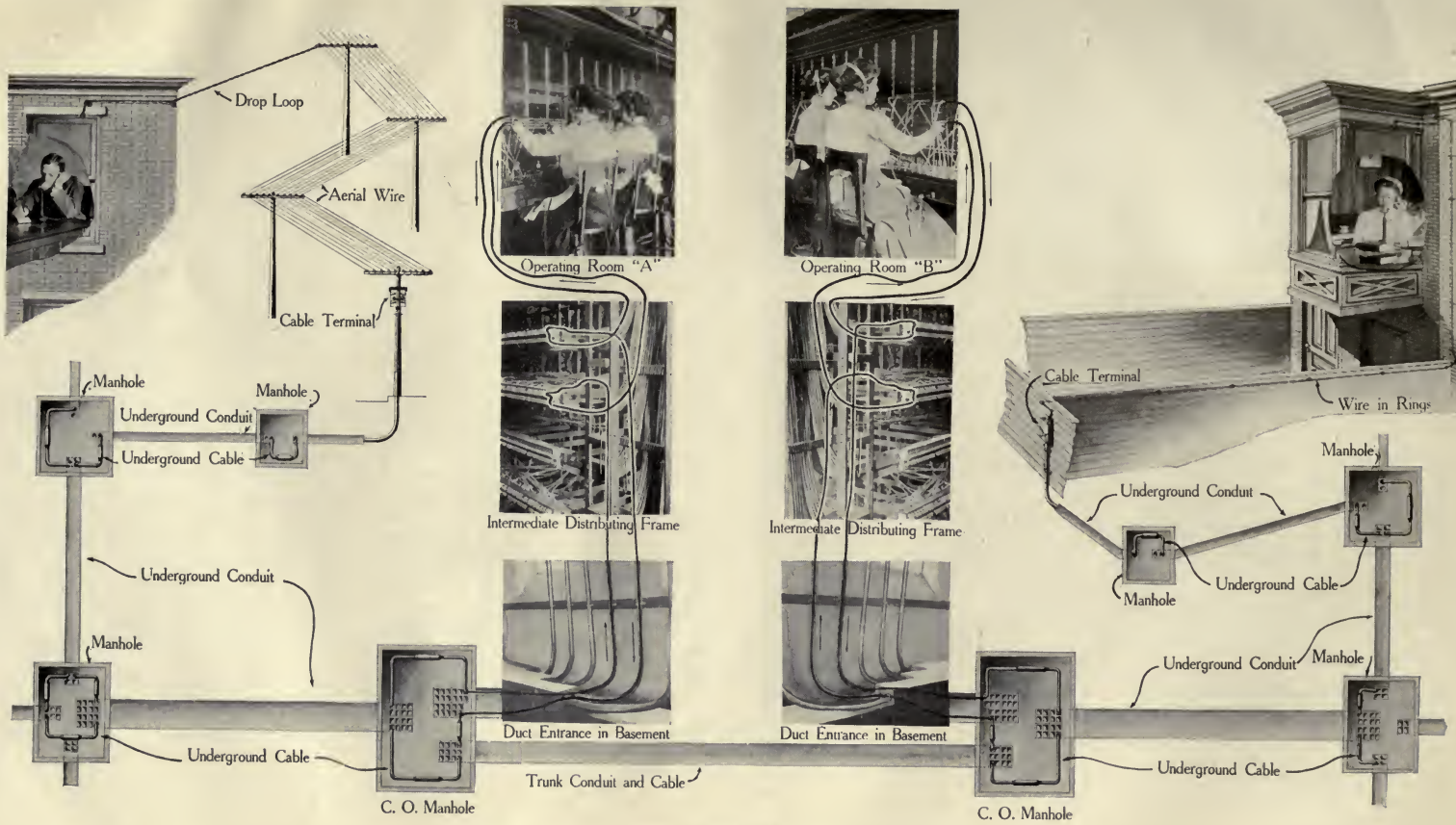



FIG. 15

DIAGRAM SHOWING TYPICAL CONNECTIONS BETWEEN TWO TELEPHONE SUBSCRIBERS.

**§151 Why Telephone Service Costs More In Large Than In Small Exchanges.**—"In a telephone company, the expenses are proportionately increased with increased demand and service." (493) Thus, when an exchange grows, the cost of furnishing the service of the unlimited use of the entire system to each subscriber increases with the number of subscribers served, for the following reasons:

1. Switchboard complexity and cost increase with number of lines. Thus, boards controlling—

| | | |
|---|---|---|
| 100-300 | lines cost about | $ 5.50 per line. |
| 300-1200 | lines cost about | 16.00 per line. |
| 1200-5000 | lines cost about | 25.00 per line. |
| 5000-25000 | lines cost about | 30.00 per line. |
| 25000-100000 | lines cost about | 33.00 per line. |
| 100000-250000 | lines cost about | 38.00 per line. |

2. Length of line per subscriber increases with number of subscribers. The average length of wire for each subscriber in a small exchange is less than 1.2 miles, while in a large exchange the average is 3.4 miles of wire.

3. The number of calls per subscriber is much greater in a large than in a small exchange, thus materially increasing the cost of handling the calls.

4. In a large exchange, the calls per subscriber are more concentrated during short periods of the day than in small exchanges, thus augmenting the peak load characteristics. See Fig. 10, p. 42.

5. The distributing system cost per subscriber is greater in a large than in a small exchange because:
   a. Poles must be larger and longer.
   b. More aerial cable must be used.
   c. Interior block distribution must be used.
   d. In many cases wires must be placed in underground cables.

e. Pavements must be torn up and replaced in construction and repair work.

f. Labor is more expensive.

g. Municipal regulations are more exacting.

6. The hazard in a large exchange is greater than in a small one because of the increased dangers from:

a. Fires in city districts.

b. Induction troubles due to proximity of other electrical conductors.

c. Conduction accidents due to short circuiting with high voltage conductors.

d. Electrolysis of underground cables.

7. The maintenance cost per subscriber increases as the exchange grows, because:

a. Exchange plant becomes more intricate and more liable to derangement.

b. More skilled labor required to look after equipment.

c. Average length of lines longer and therefore more likely to be interrupted.

d. More time required to look after longer lines.

e. Maintenance standards are higher.

8. Quicker and more exacting service standard required in a large than in a small exchange.

9. The proportion of discontinuances and moving of subscribers is much greater in a large than in a small exchange, on account of the more stable character of the population in small towns.

10. The cost of living in large cities is greater than in small towns, thus necessitating higher wages for employes.

11. Large exchanges require more skilled and more efficient employes than small exchanges.

12. Large exchanges require more non-productive labor for direction purposes than small exchanges.

13. Taxes are higher in cities than in small towns. Furthermore, cities frequently have some species of excise tax, see §115, which burdens the subscriber.

14. A city exchange building is more expensive per subscriber than an exchange building in a small town, because:

    a. Land is higher priced.

    b. More space is required to house the complicated equipment.

    c. Building and equipment must be protected against fire.

15. More reserve and unused equipment per subscriber is required in a large than in a small exchange.

16. In a city a large percentage of the service is over the trunk lines connecting the several district exchanges, thus materially increasing the length of haul. Hence, much of this service is virtually the same as "long distance" service between different exchanges.

**§152 Fire Hydrant Service of Waterworks.**—"An average of available estimates made by eminent authorities shows that the annual cost of furnishing fire protection under average conditions is about fifty per cent of the interest and other fixed charges due to cost of construction of the works, and about twenty per cent of the annual operating expenses." (131)

"It requires no demonstration to show that a large part of a water plant in every town, where the city is a user, is simply held in readiness for the purpose of fire protection. It may not be called into use very often, yet the investment is there, and is held in constant readiness." (708)

This readiness-to-serve feature is illustrated in Fig. 14, p. 54.

**§153 Economic Value of Soft Water** (74).—The daily water consumption—that is, softened by the use of soap or washing powder—in the average family, is about 10 gallons per capita. On the basis that five cents will buy 6 oz. of Ivory soap, 10 oz. Pearline, or 12 oz. Gold Dust, the number of gallons of water of different degrees of hardness—see §796 and §797—that can be softened for five cents, will be:

| Hardness, parts per million by weight | Ivory Soap | Pearline | Gold Dust |
|---|---|---|---|
| 20 | 73 | 105 | 123 |
| 25 | 65 | 91 | .. |
| 40 | 43 | 61 | 72 |
| 50 | 36 | 51 | 60 |
| 75 | 25 | 36 | 42 |
| 100 | 14 | 27 | 33 |
| 125 | 11 | 23 | 27 |
| 150 | 10 | 20 | 23 |
| 175 | 8 | 17 | 20 |
| 200 | 7 | 15 | 18 |

**§154 Relation of Safe Water Supply and Death Rate.**—"The clear and logical conclusion from the statistics is that where one death from typhoid fever has been avoided by the use of better water, a certain number of deaths, probably two or three, from other causes have also been avoided. A good water supply, used freely with confidence, results in a better general tone in the systems of the population, and so indirectly to a lower death rate, and a part of the reduction is represented by diseases having no recognized connection with the quality of the water supply." (199)

**§155 Economic Value of Human Life.**—"The financial value of a human life is generally taken, for purposes of calculation, as $5,000. The percentage fatality of typhoid fever patients is about 10 per cent. The expense of medical treatment, nursing, medicine, loss of wages and inconveniences, would doubtless be at least $100 per case, or $1,000 for the ten cases corresponding to one death. It may be fairly assumed, therefore, that $6,000 is a very moderate estimate of the financial loss to a community from typhoid fever from each death from that disease." (70)

In §154 it was shown that the infection which causes each typhoid death is also responsible for at least two deaths from other diseases. Hence, each typhoid death really means a loss of three lives, equivalent to a money value of at least $\$6,000 \times 3 = \$18,000$.

**§156 Economic Loss Due to Infected Water Supplies** (74-75).—Apart from humanitarian and esthetic views, pure water can easily be shown to be desirable from the standpoint of social economy. In the year 1900 there were 35,379 reported deaths from typhoid fever in the United States. Typhoid fever experts have found that 75 per cent of the typhoid cases are caused by infected water supplies. Hence, typhoid deaths in 1900, due to infected water—and thus preventable—were 75 per cent of $35,379 = 26,534$. The annual economic loss from these, at \$18,000—according to §155 = $\$18,000 \times 26,534 = \$477,612,000$, a sordid but forcible example of American negligence and indifference.

**§157 Quality of Water and Fire Insurance Rates.**—Curves 1 and 2 on Fig. 14, p. 54, show that, in towns of about 10,000 population and under, relative to the domestic water consumption, a much larger capacity for fire service is necessary to meet the fire insurance requirements than is needed in large towns.

Many towns that now have water supplies, adequate and safe for domestic uses, depend on emergency intake connections to polluted or infected supplies for fire protection purposes. Even a few minutes' use of an infected supply for fire purposes may saturate the distributing system with deadly bacteria that will cause an extensive epidemic. Public sentiment regarding the use of polluted water, whether from ordinary or emergency sources, is rapidly crystalizing against this unjustifiable and inhuman practice, rightly holding that economically it may be better and cheaper—see §156—to sustain a fire loss than a typhoid, dysentery or cholera epidemic. For this reason, in most cases in the future, the water that will be available for fire fighting purposes will be limited to that which is safe for domestic uses.

If the water has a tendency to produce mineral, vegetable or animal growths in the mains as described in §343, §344 and §345, and illustrated in Fig. 28, p. 112, the carrying capacity of the mains may be very much decreased, as shown in the results of the tests given in Table 15, p. 250. The smaller mains in many waterworks systems have become practically worthless for fire fighting purposes on account of these growths.

The preceding facts show that fire insurance companies ought to consider water quality in fixing fire insurance rates.

**§158 Electrolysis and Fire Insurance Rates.**—The economic waste produced by the electrolysis—see Chapter 9—of underground Utility structures, altho gigantic, is little appreciated. The close relation existing between certain fire hazards and electrolysis is shown in §447 and §448. Hence it is evident that, where water, heating or gas mains or lead cable sheaths act as carriers of street railway return current—see §396—the fire hazard is much greater than where the street railway takes proper care of its return current on its own property, and, as a result, fire insurance rates ought to be correspondingly higher.

Where the return current is not properly taken care of by the street railway, the water mains will probably be weakened by electrolysis. This will not only decrease their efficacy for fire fighting purposes, but may cause the mains to fail entirely at a critical time, thus leaving not only the burning risk, but other adjacent insured risks without adequate fire protection and at the mercy of the elements. This condition is especially dangerous with direct-pressure waterworks systems where the pressure in the main is increased for fire purposes. On account of the subtle nature of the corrosion of cast iron, as discussed in §414, a cast iron water main might not leak under domestic pressure conditions, and yet fail instantly and completely when the normal fire pressure is applied.

The destruction of gas mains by electrolysis, and especially service lines going into basements, as shown at the top of Fig. 36, p 140, makes it easy for the gas to leak and produce conditions favorable for destructive gas explosions. Several accidents, resulting in much property destruction, have been caused in this way. The heavier the gas—see §730—the less will be its tendency to blow away and the greater will be its tendency to settle in basements and await the fatal spark that will convert it into a titanic destructive agency.

The bursting of water mains weakened by electrolysis may flood basements and damage much property.

**§159 Artificial Gas Service Characteristics.**—These are:

1. Liable to be placed in competition with natural gas, thus having its earnings curtailed or probably destroyed, if located within about 200 miles of an adequate natural gas field.

2. Raw fuel cost is large element of total operating cost, as shown in Fig. 11, p. 46.

3. Coal and petroleum products used in making gas not only fluctuate in price, but have had a marked increase in price in the last few years, as shown by curves 4 and 5 of Fig. 2, p. 28.

4. Difficult to determine an adequate fixed rate for gas on account of factors 2 and 3.

5. Extension and improvement of electric lighting service is crowding out artificial gas for illuminating service.

6. Underground structures represent about one-half of total investment.

7. Underground structures liable to serious damage from electrolysis.

8. Liability for gas explosions from leaks in plant.

**§160 Electric Power Service Characteristics.**—These may be summarized as follows:

1. Rapid changes in art of electric power generation in past.

2. Large variation in load, with marked peak;—see Fig. 7, p. 39.

3. Demands for service must be met instantaneously.

4. Time and number of hours use of service have vital bearing on cost of service;—see Fig. 12, p. 47.

5. Fluctuation in voltage produces adverse lamp operating conditions;—see Fig. 45, p. 224.

6. Depreciation of equipment is relatively fast.

7. Fixed charges form a large part of total operating cost;—see Fig. 11, p. 46.

8. Additional investment must be made to reach each new consumer.

**§161 Heating Service Characteristics.**—These are:

1. Limited geographically to cold climate.

2. Seasonal nature of load; equipment is idle ordinarily at least half of each year.

3. Fixed charges are an important item of total cost.

4. Fluctuation in fuel price may make accurate rate fixing for a period of years difficult.

5. Additional investment must be made to reach each new consumer.

**§162 Natural Gas Service Characteristics.**—These may be summarized as follows:

1. Public does not appreciate true value of natural gas service as compared with other heating and lighting services or heating and lighting commodities;—see Fig. 6, p. 37.

2. Public does not appreciate large investment necessary to transmit gas from the gas field to the consumer's premises;—see Fig. 13, p. 52.

3. Depletion of all gas fields is very rapid;—see Fig. 29, p. 119.

4. Useful commercial life of plant is limited by commercial life of gas fields.

5. Utility has no control whatever over quantity or quality of gas supply, and is entirely at Nature's mercy.

6. Investment hazard is greater than that of any other Utility.

7. Fixed charges are larger than for any other Utility. See Fig. 11, p. 46.

8. Large variation in daily load. See Fig. 9, p. 41.

9. Large variation in seasonal load. See Fig. 9, p. 41.

10. Must make large investment that is used only for a short period each year to take care of the peak load service. See §117.

11. Must carry large investment in non-productive leased ground in order to be able to maintain an adequate reserve supply of gas for future use.

12. Underground structures represent major part of investment.

13. Underground structures liable to serious damage from electrolysis.

14. Shrinkage in volume of gas due to leakage in transmitting from gas field to consumer is enormous.

15. Liability for gas explosions from leaks in plant.

16. Each new consumer requires an additional investment.

17. Many rate schedules have ignored relative worth of natural gas service as shown in Fig. 6, p. 37, and cost factors shown in Fig. 42, p. 188.

**§163 Telegraph Service Characteristics.**—These are:

1. Public cannot use service directly, as is the case in all other Utilities, but must deal thru skilled operators.

2. Labor cost of skilled operators is an important element of service cost, especially in view of the upward tendency of wages.

3. Nearly all of the investment is exposed to the elements.

4. Rapid depreciation of plant.

5. Competition from telephone for rendering an equivalent service.

6. Can render best and most economical service when co-operating with telephone Utility.

**§164 Telephone Service Characteristics.**—These may be summarized as follows:

1. Natural monopoly features more marked than in any other Utility.

2. More property duplicated and therefore economically wasted than with any other Utility. See Fig. 1, p. 27.

3. Personal nature of service.

4. Each subscriber interested in possibility of securing service with every other subscriber.

5. Value of service per subscriber increases as number of subscribers increases.

6. Cost of service per subscriber increases as number of subscribers increases.

7. Cost of service per unit of service decreases as number of subscribers increases.

8. Rapid changes in art in past.

9. Large amount of investment exposed to ravages of elements.

10. "Telephone service is hazardous, and the property is subject to great and rapid deterioration from exposure to the weather and other causes." (493)

11. Rapid depreciation of plant.

12. Induction and conduction troubles. See §765 and §766.

13. All underground metal structures in danger of electrolysis damages.

14. Has no over-load margin.

15. Load has tendency to have marked peaks.

16. Cost of changing instruments, due to moving of subscribers, is an important element of total service cost.

17. Wages and salaries form one-half of total operating expense; this is especially pertinent on account of the upward tendency of these two items.

18. Each new subscriber requires an additional capital investment.

**§ 165 Transportation Service Characteristics.** — These may be summarized as follows:

1. Labor cost is an important element of service cost, especially since there has been such a marked increase in wages. See §98.

2. Liability for accidents to patrons and property.

3. Nearly all of the investment is exposed to the ravages of the elements.

4. Load is frequently one way only, thus necessitating return of empty cars.

5. Empty car return cost is part of true service cost.

6. Traffic is largely seasonal.

7. Passenger traffic is frequently concentrated, thus producing marked peak loads.

8. The riding habit on street railways increases much faster than the population.

9. Competition between electric traction, steam railroads, and water transportation Utilities for rendering equivalent services.

**§166 Water Works Service Characteristics.**—These may be summarized as follows:

1. No other Utility is so closely and vitally related to the general health of the community.

2. Adequate service requires delivering of water that is safe for all domestic uses.

3. All surface and some underground water supplies are in constant danger of pollution, and must be watched continually by the Utility.

4. Commercially useful life of plant is dependent on continuity of adequate and safe water supply.

5. Plant is community's principal defense against fire ravages.

6. Large part of investment is used only for fire service.

7. Large part of plant is underground.

8. All underground structures liable to be injured by electrolysis.

9. Each new consumer requires additional investment to plant.

Law is the last result of human wisdom acting upon human experience for the benefit of the public.
—Dr. Johnson.

# Chapter 4

## GOVERNMENTAL POWER TO REGULATE

**§167 Co-Ordination of Government Powers.**—This is shown in Fig. 16, p. 68.

**§168 What Is Public Interest?**—"Private property becomes clothed with public interest when used in a manner to make it of public consequence, and affect the community at large." (311)

"When one devotes his property to a use in which the public has an interest, he, in effect, grants to the public an interest in that use, and must submit to be controlled by the public for the common good, to the extent of the interest he has thus created. He may withdraw his grant by discontinuing the use; but, so long as he maintains the use, he must submit to the control." (311) "There is no attempt to compel the owner to grant the public an interest in his property, but to declare his obligations if he use it in this particular manner." (314). "When private property is devoted to public use, it is subject to public regulation." (313) "Where property has been clothed with a public interest, the legislature may fix that which in law shall be reasonable for its use." (317)

**§169 Public Monopoly.**—"There is no doubt that the general principle is favored, both in law and justice, that every man may fix what price he pleases upon his property, or the use of it; but, if for a particular purpose the public have a right to resort to his premises and make use of them, and he have a monopoly in them for that purpose, if he will take the benefit of that monopoly, he must as an equivalent perform the duty attached to it upon reasonable terms." (312)

"When an employment or business becomes a matter of such public interest and importance as to create a common charge or burden upon the citizen, in other words, when it becomes a practical monopoly, to which the citizen is compelled to resort, and by means of which a tribute can be exacted from the community, it is subject to regulation by the legislative power." (226) For "it is within the power of the government to regulate prices at which water shall be sold by one who enjoys the virtue and monopoly of the sale." (337)

# FIG. 16
# GOVERNMENTAL POWERS TO REGULATE UTILITIES

- **I PUBLIC INTEREST**
  - 1-WHAT IS
  - 2-IN MONOPOLY
  - 3-OBLIGATIONS
    - LINKED WITH
    - CANNOT BE SOLD
  - 4-FIRST IMPORTANCE
- **II POWER**
  - 1-FORM
    - INHERENT
    - ACTIVE
    - PRECEDENT NOT NECESSARY
    - DORMANT
    - DELEGATED
  - 2-SCOPE
    - NOT NEW
    - PENALTIES
    - LIABILITY OF CORPORATION OFFICIALS
    - TO SECURE UTILITY RECORDS
    - OF RATE FIXING POWER
    - STATES POWER OVER FOREIGN CORPORATIONS
    - VALIDITY OF PART OF A STATUTE
  - 3-FEDERAL
    - UNITY
    - WHEN STATE LINES CEASE
    - SUPREMACY
  - 4-STATE, WHERE SUPREME
  - 5-POLICE
    - WHAT IS
    - SUPREMACY
    - SCOPE
  - 6-EMINENT DOMAIN
    - WHAT IS
    - NO EXCEPTIONS TO
    - DOES NOT DESTROY CONTRACTS
    - MAY BE DELEGATED
    - VALUATION OF CONDEMNED PROPERTY
  - 7-MUNICIPAL
    - INDEPENDENT OF STATUATORY PROVISION
    - TO CONTROL WATER SUPPLY
    - TO BUILD COMPETING WATER PLANT
    - TO COMPEL CONTINUOUS SERVICE
    - TO CANCEL WATER CONTRACT
    - TO COMPEL CONTRACT OBSERVANCE
    - NEED NOT BUY OLD WATER PLANT
  - 8-TO PREVENT COLLECTION FOR WORTHLESS SERVICE
- **III FRANCHISE**
  - 1-EXCLUSIVE GRANTS
  - 2-CHARTER PROTECTION
  - 3-PUBLIC GIVEN BENEFIT OF DOUBT
  - 4-AMBIGUOUS GRANTS
  - 5-NO RIGHTS GRANTED BY IMPLICATION
  - 6-SPECIAL PRIVILEGE GRANTS MUST BE EXPLICIT
  - 7-GOVERNMENTAL INTEREST SUPERIOR TO PRIVATE
  - 8-ONLY OPEN DEALING SANCTIONED
  - 9-EMINENT DOMAIN SUPERIOR TO
  - 10-MERELY PROPERTY
  - 11-DUTIES GOING WITH

**§170 Obligations Linked With Public Interest.**—The doctrine that a business, carried on under the special privilege of a franchise, clothes the business with a public interest and places it under legislative control, has often been asserted by the United States Supreme Court. (346, 349, 371)

**§171 Public Obligations Cannot Be Sold.**—Without legislative authority, a Utility cannot sell its property and franchise to another party, in such a way as to take away its power to perform its public duties. (367, 329)

**§172 Public Interest of First Importance.**—"The power, whether called police, governmental or legislative, exists in each State by appropriate enactments not forbidden by its own constitution or by the constitution of the United States, to regulate the relative rights and duties of all persons or corporations within its jurisdiction and therefore to provide for the public convenience and the public good." (437)

"The State which created the corporation may make reasonable regulations to secure the safety, good order, convenience and comfort of the public." (417)

"The Companies hold a public franchise; therefore governmental supervision is valid. They are organized for the public interests and to subserve primarily the public good and convenience." (454)

"The duties required of corporations by their charters do not create any limitation upon the State against imposing all such further duties as may be deemed essential or important for the safety of the public, the security of passengers and employes, or the protection of the property of adjoining owners." (382)

**§173 Inherent Power.**—The inherent right of the State to regulate public utilities has been recognized for centuries. "Under the powers inherent in every sovereignty, a government may regulate the conduct of its citizens toward each other and, when necessary for the public good, the manner in which they shall use their property." (310)

"When one becomes a member of society, he necessarily parts with some rights and privileges which, as an individual not affected by his relations to others, he might retain." (309)

**§174 Active Power.**—"The legislature has the authority, in every case, where its power has not been restrained by contract, to proceed upon the ground that the public may not rightfully be required to submit to unreasonable exactions for the use of a Utility established and maintained under legislative authority." (412)

**§175 Precedent for Regulation Not Necessary.**—"Neither is it a matter of any moment that no precedent can be found for a statute precisely like this. It is conceded that the business is one of recent origin, and that its growth has been rapid, and that it is already of great importance; and it must also be conceded that it is a business in which the whole public has a direct and positive interest. It presents, therefore, a principle in social science, and this statute simply extends the law so as to meet this new development of commercial progress." (314)

**§176 Dormant Power.**—Absence of local or State laws does not insure immunity from rate regulation. Rate-prescribing legislation may be enacted at any time. In such a case the power would be dormant, but could be exercised at any time, as is evident from the following: "It is a matter of no importance that the power of regulation now under consideration was not exercised for more than twenty years after the company was organized. A power of government which actually exists is not lost by non-use." (316)

**§177 Delegated Power.**—"No legal principle is better established than the rule that the power to fix rates, if delegated by the legislature to a commission, is in kind a legislative function and that courts of equity will not interefere in advance by injunction to control the exercise of such a power." (477, 534)

"A by-law or ordinance of a municipal corporation may be such an exercise of legislative power delegated by the legislature to the corporation as a political subdivision of the State, having all the force of law within the limits of the municipality, that it may properly be considered as a law, within the meaning of the article of the Constitution of the United States." (352, 376, 435, 457)

"There can be no doubt of the general power of a State to regulate, and this regulation can be carried on by means of a commission. Such a commission is merely an administrative board created by the State for carrying into effect the will of the State as expressed by its legislation." (391)

**§178 Regulative Power Not New.**—"The great office of statutes is to remedy defects in the common law as developed, and to adapt it to the change of time and circumstances. The limitation by legislative enactment of the rate of charge for services rendered in a public employment, or for the use of property in which the public has an interest, establishes no new principle in the law, but only gives effect to an old one." (315)

"To limit the rate of charges for services rendered in a public employment, or for the use of property in which the public has an interest, is only changing a regulation which existed before." (356)

**§179 Penalties.**—"There is no inhibition upon a state to impose such penalties for disregard of its police regulations as will insure prompt obedience to their requirements." (382)

"The imposition of punitive or exemplary damages cannot be opposed as in conflict with the prohibition against the deprivation of property without due process of law. It is only one mode of imposing a penalty for the violation of a duty, and its propriety and legality have been recognized by repeated judicial decisions." (359)

**§180 Liability of Corporation Officials.**—"A lawful command to a corporation is in effect a command to its officers, who may be punished for contempt for disobedience of its terms." (509)

**§181 Power to Secure Utility Records.**—A corporation is under duty to produce records, books and papers in its possession when they may be properly required in the administration of justice. (508)

**§182 Extent of Rate-Fixing Power.**—The United States Supreme Court has several times sustained the doctrine that the State may fix, within constitutional limits, the rates for use and may regulate all property devoted to public use, and in which the public, by virtue of it being required to use such property, has an interest. The question of the form of ownership is not considered at all because the doctrine applies to all forms of ownership, working the same for an individual partnership or corporation. (307, 349, 373)

**§183 State Power Over Foreign Corporations.**—"The principle, that the right of a foreign corporation to engage in business in a State other than that of its creation depends solely upon the will of such other State, has been settled by the Court." (397) "The only limitation upon this power of the State to exclude a foreign corporation is where its business is strictly commerce, interstate or foreign." (353)

**§184 Validity of Part of Statute.**—"It is familiar law that one section or part of an act may be invalid without affecting the validity of the remaining portion of the statute. Any independent provision may be thus dropped out if that which is left is fully operative as a law, unless it is evident from a consideration of all the sections that the legislature would not have enacted that which is within, independently of that beyond its power." (392)

"When the objectionable part of a statute is eliminated, if the balance is valid and capable of being carried out, and if the court can conclude it would have been enacted if that portion which is illegal had been omitted, the remainder of the statute thus treated is good." (392, 476, 492)

**§185 Unity of Federal Government.**—"In all commercial regulations, the United States form a single nation." (287)

**§186 When State Lines Cease.**—"In matters of foreign and interstate commerce there are no State lines; in such commerce, instead of the State a new power and a new welfare appear that transcend the power and welfare of any State." (507)

**§187 Supremacy of Federal Government.**—"When a State statute and a Federal statute operate upon the same subject matter and prescribe different rules concerning it, and the Federal statute is one within the competency of Congress to enact, the State statute must give way." (401, 422)

**§188 Where State Is Supreme.**—"In purely State matters, and where no Federal constitutional rights are involved, the State is supreme, for "the sovereignty of a state in the exercise of its legislation is not to be impaired unless it be clear that it has transcended its legitimate authority." (285)

**§189 What Is Police Power?**—"Police powers are nothing more or less than the powers of government inherent in every sovereignty; that is to say, the power to govern men and things." (290) "How far the police power goes must be left for decision in each case as it arises." (415)

**§190 Supremacy of Police Power.**—"All rights are subject to the police power of the State; and if public safety or morals require the discontinuance of any manufacture or traffic, the legislature may provide for its discontinuance, notwithstanding an individual or corporation may suffer inconvenience." (321)

**§191 Scope of Police Power.**—This "is universally conceded to include everything essential to public safety, health and morals, and to justify destruction or abatement by summary proceedings of whatever may be regarded as public nuisances." (386)

"The police power extends to all the great public needs. It may be put forth in aid of what is sanctioned by usage, or held by the prevailing morality of strong and preponderant opinion to be greatly and immediately necessary to the public welfare." (506)

"A business once harmless and lawful, vested even under chartered rights, which later becomes hurtful to the public under an altered condition of things, may be restricted in its transactions, or indeed utterly prohibited under the action of State or municipal legislation touching it." (32 citing 322)

Numerous legislative enactments, based on the preceding doctrine, have been passed. In reviewing some of these, the United

State Supreme Court has established doctrines that make a Utility liable:

1. For fires caused by its locomotives. (414, 443)
2. To servants, for negligence of fellow servants. (358, 446)
3. To a fine, for failure to build a fence along right of way. (359)
4. For cost of fence, and can be compelled to inclose right of way. (343, 381)
5. To adjacent property owners for failure to protect right of way. (381)
6. For expense of removal of grade crossings. (385, 453)
7. To be restricted in use of steam locomotives within city limits. (320)
8. For special tax out of receipts, to pay cost of regulation. (370)
9. To governmental control for construction work on streets. (375)

**§192 Power of Eminent Domain.**—"Eminent domain is the power under which the State may appropriate private property for public purposes upon making, according to the principles of natural equity, compensation to the owner. The power is the offspring of political necessity." (21)

This power is an incident to sovereignty, and its exercise is often essential to advance the public interests. All property, whether owned by an individual or individuals, a corporation aggregate or sole, is within the term. The only question that may ever be raised is on the adequacy of the compensation, for a just price must be paid. (291)

**§193 No Exceptions to Power of Eminent Domain.**—"All private property is held subject to the demands of a public use. The constitutional guarantee of just compensation is not a limitation of the power to take, but only a condition of its exercise, whenever public uses require, the government may appropriate any private property on the payment of just compensation." (419)

**§194 Eminent Domain Does Not Destroy Contracts.**—"The right of eminent domain in government in nowise interferes with the inviolability of contracts; the most sanctimonious regard for the one is perfectly consistent with the possession and exercise of the other." (292)

**§195 Power of Eminent Domain May Be Delegated.**—"The legislature may in its discretion exercise the power of eminent domain directly or thru agents, authorizing individuals to appropriate private property when the public interest requires such a course." (21 citing 306)

**§196 Valuation of Condemned Property.**—"In determining the value of property that has been legally condemned, the inquiry must be: 'What is the property worth in the market, viewed, not merely with reference to the uses to which it is at the time applied, but with reference to the uses to which it is plainly adapted; that is to say, what is its worth from its availability for valuable uses?' Property is not to be deemed worthless because the owner allows it to go to waste, or to be regarded as valueless because he is unable to put it to any use. Its capability of being made available gives it a value." (324)

**§197 Regulation Power Independent of Statutory Provision.**—"Independent of statutory provision, it is the province and the duty of the municipality, whenever opportunity offers, to exercise its power in the protection of its inhabitants against extortion, and to secure them utility services from Utilities assuming to furnish them at reasonable rates." (584)

**§198 Municipality's Duty to See That Its Citizens Have Adequate Water Supply.**—"No higher police duty rests upon municipal authority than that of furnishing an ample supply of pure and wholesome water for domestic and public uses." (504)

"If a municipality elect to contract with another for the discharge of this function, it is under the greatest obligation to require that the contractor shall engage to construct and maintain adequate means and furnish an adequate supply in quality and quantity, to meet the public necessity at all times." (504)

**§199 When Municipality May Build Its Own Plant.**—"Altho the contract between a water works company and a municipality provided that no contract or privilege would be granted to furnish water to any other person or corporation, the City was not, in the absence of a special stipulation to that effect, precluded from establishing its own independent system of water works." (469)

**§200 Utility Contract Requires Continuous Performance.**—"The obligation of the Utility to furnish the quantity and quality of water required by the contract was a continuing obligation, and not met once for all by a test. The right of the Utility to enjoy the consideration of the contract was to depend upon its continuing to perform it." (361)

"The continuing character of the obligation to furnish an adequate supply of wholesome water is not met by showing that such a supply has been furnished at times, nor is the non-performance of the agreement excused by the occurrence of conditions which are likely to occur in a climate of long dry summers." (505)

**§201 When a Municipality May Cancel Contract.**—"When the contractor under a municipal water supply contract wholly fails to

furnish an adequate supply of pure water according to the contract; the municipality has no adequate remedy at law; it may treat the contract as ended and a court of equity may enforce such recession." (503)

**§202 Utility Contract Must Be Complied With to Be Protected.**—"The enforcement of a municipal ordinance will not be enjoined as impairing the obligations of an existing contract at the instance of a complainant who fails to show that the contract has been complied with." (503)

**§203 When a Municipality Need Not Buy Old Plant.**—"Where a water company has wholly failed to live up to its contract and the municipality has determined by ordinance to erect its own plant, a court of equity cannot, in a suit brought by the water company to restrain the municipality on the ground of impairment of contract, require the municipality to purchase any part of the plaintiff's plant as a condition for dismissing the bill." (503)

**§204 Utility Cannot Collect for Worthless Service.**—"It is inequitable that a corporation, chartered to serve a public use and actually undertaking to serve the public with one of the necessaries of life, should be allowed to collect the price of a supply of good water from those to whom it delivers an article that cannot be used or be made fit for use. The company will be enjoined from collecting water rents where it has supplied water utterly unfit for domestic use or for steam purposes." (606)

**§205 Exclusive Grants.**—"Exclusive grants are strongly disfavored by the law and nothing but express words conferring such exclusive privileges will confer them. The presumption is always strong that the legislature or the municipal corporation which is claimed to have granted such monopoly, did not intend so to do: it must be clear beyond all question that the act claimed to vest such exclusive right does in fact do so by letter." (32 citing 289)

"The rule of construction in this class of cases is that it shall be most strongly against the corporation. Every reasonable doubt is to be resolved adversely. Nothing is to be taken as conceded but what is given in unmistakable terms or by an implication equally clear. The affirmation must be shown. Silence is negation, and doubt is fatal to the claim. This doctrine is vital to the public welfare. It is axiomatic in the jurisprudence of this Court." (323, 407)

**§206 Charter Protection.**—"Grants of immunity from legitimate governmental control are never to be presumed; unless an exemption is clearly established, the legislature is free to act on all subjects

within its general jurisdiction, as the public interests may require." (335) However, "a grant in the Constitution of a State of a privilege to a corporation is not subject to repeal or change by the legislature of the State." (350)

It must be distinctly understood that this immunity may be destroyed by the people changing their State Constitution. For, "the contracts which the (Federal) Constitution protects are those that relate to property rights, not governmental. All that one can get from such a charter is a suspension of certain governmental rights in his favor, subject to withdrawal at will. He has in legal effect nothing more than a license to enjoy the privilege on the terms named for the specified time, unless it be sooner abrogated by the sovereign power of the State. It is a permit, good as against existing laws, but subject to future constitutional control or withdrawal." (334)

**§207 Public Given Benefit of Doubt.**—"Statutory grants are to be construed strictly in favor of the public and whatever is not unequivocally granted is withheld." (469)

"It is one of the contingencies to which parties look now in making a large class of contracts that they may be affected in many ways by State and National legislation. If parties wish to guard against contingencies of that kind, they must do so by such clear and explicit language as will take their contracts out of the established rule that public grants, susceptible of two constructions, must receive the one most favorable to the public." (377)

**§208 Ambiguous Grants.**—"Public grants are to be construed strictly, and any ambiguity in the terms of the contract must operate against the corporation and in favor of the public; and the corporation can claim nothing but what is clearly given by the act." (294)

**§209 No Rights Granted By Implication.**—"In grants by the public, nothing passes by implication. Doubts as to their interpretation are to be solved in favor of the State." (369)

**§210 Special Privilege Grants Must Be Explicit.**—"Only that which is granted in clear and explicit terms passes by a grant of property, franchises or privileges in which the Government or the public has an interest." (318, 322, 355, 368)

"Altho a legislative grant to a corporation of special privileges may be a contract when the language of the statute is so explicit as to require such construction, yet if one of the conditions of the grant be that the legislature may alter or revoke it, a law altering or revoking the exclusive character of the granted privilege cannot be regarded as one impairing the obligation of the contract." (376)

**§211 Governmental Interest Superior to Private Interest.**—"It is a familiar rule of construction that, where a statute operates as a grant of public property to an individual, or the relinquishment of a public interest, and there is a doubt as to the meaning of its terms or as to its general purpose, that construction should be adopted which will support the claim of the government rather than the individual." (339)

**§212 Open Dealing Only, Sanctioned.**—The preceding doctrine is a wise one. "It serves to defeat any purpose concealed by the skillful use of terms, to accomplish something not apparent on the face of the act, and thus sanctions only open dealing with legislative bodies." (340)

**§213 Eminent Domain Superior to Franchise Rights.**—"A distinction has been attempted between the power of a government to appropriate for public uses property which is corporeal or may be said to be in being, and the like power in the government to resume or extinguish a franchise. The distinction thus attempted we regard as a refinement which has no foundation in reason. We are aware of nothing peculiar to a franchise which can class it higher, or render it more sacred, than other property; and a grant of a franchise is not in point of principle distinguishable from a grant of any other property." (293, 421)

"The rights and franchise which have become vested upon the faith of contracts can be taken by the public, upon just compensation to the company, under the State's power of eminent domain. In that way the plighted faith of the public will be kept with those who have made large investments upon the assurance by the State that the contract with them will be performed." (345)

**§214 Franchise Is Merely Property.**—"A franchise is property and nothing more. It is its character of property only which imparts to it value." (293, 421)

**§215 Duties Going With Franchise.**—"A franchise is a right, privilege, or power of public concern which ought not to be exercised by private individuals at their mere will and pleasure, but should be reserved for public control and administration, either by the government directly, or by public agents, acting under such conditions and regulations as the government may impose in the public interest and for the public security." (357)

# FIG. 17
# PROTECTION OF UTILITIES FROM ADVERSE REGULATION

- **I** HOSTILE LEGISLATION
  - 1- FEDERAL
  - 2-STATE
- **II** 14TH AMENDMENT U.S. CONSTITUTION
  - 1-SCOPE
    - FAR REACHING IMPORTANCE
    - APPLIES TO ALL CLASSES
    - CORPORATION SAME AS PERSON
    - COVERS ALL FORMS OF PROPERTY
  - 2-INSURES
    - SQUARE DEAL FOR ALL
    - DUE PROCESS OF LAW
    - EQUAL PROTECTION OF LAWS
    - OPERATION OF "LAW OF THE LAND"
    - COURT REVIEW
    - SUPREMACY OF FEDERAL POWER
  - 3-LIMITS
    - STATES RIGHTS
    - RATE REGULATION POWER
    - STATE OFFICERS' POWERS
    - POLICE POWER
      - ABUSE
      - BY FEDERAL CONSTITUTION
  - 4-APPLIES TO ALL DELEGATED POWER
- **III** VESTED RIGHTS
  - 1-WHAT ARE
  - 2-MUST BE PROTECTED
  - 3-NOT LIMITED BY LIFE OF CORPORATION
- **IV** EXCLUSIVE GRANTS
  - 1-TESTS
    - MUST BE CONSTITUTIONAL
    - BASED ON VALID LEGISLATION
    - CONTRACT BETWEEN STATE AND GRANTEE
    - MUST HAVE VESTED RIGHTS
  - 2-CLASSES
    - NO CONTRACTUAL RELATION
    - HAVING CONTRACTUAL RELATION
- **V** STATES CANNOT TAX FEDERAL FRANCHISES
- **VI** WHEN UTILITIES MAY CEASE GIVING SERVICE
- **VII** GOVERNMENTAL POWER
  - 1-WHO MAY SURRENDER
  - 2-WHEN RATE REGULATING POWER MAY BE SUSPENDED
- **VIII** UNPROFITABLE SERVICE EXTENSIONS NEED NOT BE MADE BY UTILITY

A government without justice is unworthy the name thereof.
—Bishop John P. Newman.

# Chapter 5

## PROTECTION OF UTILITIES FROM ADVERSE LEGISLATION

**§216 Co-Ordination of Protective Doctrines.**—This is shown in Fig. 17, p. 78.

A Utility that is forced to appeal to the courts to prevent the confiscation of its property by unfair regulation is not being fairly dealt with and cannot render the service that it could if the doctrines laid down in chapters 1 and 3 were followed in framing the regulative legislation.

**§217 Hostile Federal Legislation.**—The 5th Amendment of the Constitution of the United States, reading as follows: "No person shall be deprived of life, liberty, or property, without due process of law; nor shall private property be taken for public use, without just compensation," may give adequate protection against adverse regulation at the hands of the federal government. However, since federal regulation can apply only to interstate affairs, this amendment does not reach intrastate business.

**§218 Hostile State Legislation.**—The 14th Amendment of the Constitution of the United States, reading as follows: "* * * nor shall any State deprive any person of life, liberty or property, without due process of law, nor deny to any person within its jurisdiction the equal protection of the laws," is always a strong safeguard and, if properly invoked, ought to be a strong bulwark against local injustice, oppressive legislation, irrational or illegal regulation. This Amendment does not create any new rights or establish any new privileges. Its function is preservative rather than creative. It merely takes official cognizance of pre-existing rights and privileges, and pledges the strong arm of the supreme power of the land,—namely, the judiciary of the federal government,—to the protection of such rights and privileges.

**§219 Importance of 14th Amendment.**—Justice Miller, in speaking of the duty of the court in construing the 14th Amendment, then for the first time said: "We do not conceal from ourselves the great responsibility which this duty devolves upon us. No questions so far-reaching and pervading in their consequences, so profoundly interesting to the people of this country and so important

in their bearing upon the relations of the United States, and of the several States to each other and to the citizens of the States and of the United States, have been before this court during the official life of any of its present members." (305)

**§220 14th Amendment Applies to All Classes.**—The general opinion has been that this Amendment was made for the benefit of the negro. This however is erroneous. For, "the congressional committee that drafted the Amendment had been appealed to by individuals and corporations for protection against discriminating and unfair State and local taxation, and the committee intended to give the amendment the broadest possible scope and operation for the benefit of all persons, whether white or black." (101)

"It is universal in its application, extending its protective force over all men, of every race and color, within the jurisdiction of the States throughout the broad domain of the Republic." (511)

**§221 Corporation Same As Person.**—"It is now settled that corporations are persons within the meaning of the constitutional provisions forbidding the deprivation of property without due process of law, as well as a denial of the equal protection of all the laws." (411)

**§222 Property.**—"Anything in which the law allows ownership by man is property under the 14th Amendment. It may be real, personal or mixed; corporal or incorporal; a franchise, contracts or anything capable of beneficial ownership." (32)

**§223 14th Amendment Insures Square Deal for All.**—The 14th Amendment "stands in the Constitution as a personal shield against all unequal or impartial legislation by States, and injustice which follows it, whether directed against the most humble or the most powerful." (32 citing 348)

**§224 Due Process of Law.**—This clause is intended to protect the individual or corporation from the arbitrary exercise of the powers of government, whether federal, state or delegated, when such exercise is not in conformity with the established principles of private right. For the power of government can legally be used only when acting in accordance with those general rules established in our system of jurisprudence for the security of private right. "Due process of law" is not a protection against governmental action per se, but protection against any action that does not permit the injured party being heard in his own defence. (21)

"Due process of law, within the meaning of the Constitution, is secured when the laws operate on all alike, and no one is subjected to partial or arbitrary exercise of the powers of government." (365)

" 'Due Process of law' means the same as the words 'law of the land' in Magna Charta." (295)

**§225 Equal Protection of Laws.**—"The inhibition that no state shall deprive any person within its jurisdiction of the equal protection of the laws was designed to prevent any person or class of persons from being singled out as a special subject for discriminating and hostile legislation." (354)

**§226 What Is the Law of the Land?**—"By 'law of the land' is most clearly intended the general law, which hears before it condemns; which proceeds upon inquiry and renders judgment only after trial. Everything which may pass under the form of an enactment is not law of land." (284)

" 'Law of the land' and 'due process' are the same in meaning." (319)

**§227 Court Review Insured.**—"The duty rests upon all courts, Federal and State, when their jurisdiction is properly invoked, to see to it that no right secured by the law of the land is impaired or destroyed by legislation." (425)

"It has always been a part of the judicial function to determine whether the act of one party, whether that party be a single individual, an organized body or the public as a whole, operates to divest the other party of any rights of person or property." (394) "This court has declared in several cases that there is a remedy in the courts for relief against legislation establishing a tariff of rates which is so unreasonable as to practically destroy the value of property of companies engaged in business." (399)

**§228 Supremacy of Federal Power.**—In all questions concerning the use or abuse of congressional, state or delegated power over Utilities, the Supreme Court of the United States is the final arbiter. From it there is no appeal. The right of the U. S. Supreme Court to pass final judgment is no longer questioned. (296, 304) "Wherever commerce among the states goes, the power of the nation, as represented in the U. S. Supreme Court, goes with it to protect and enforce its rights." (301)

Whenever any conflict arises between the enactments of the federal and state authorities, those of the federal government have supremacy until the validity of the different enactments are determined by the Federal courts. "The sufficiency of rates with reference to the Federal Constitution is a judicial question, and one over which Federal courts have jurisdiction by reason of its Federal nature." (472)

**§229 Limitation of State's Rights.**—The old idea of unlimited sovereign state rights is obsolete. When constitutional rights are involved, all the states and their delegated agencies are amenable to the Federal power. "Every addition of power to the general government involves a corresponding diminution of the governing power of the States. It is simply carved out of them." (328)

**§230 Limitation of Rate Regulative Power.**—The governmental power to regulate rates "can not be exercised tyranically, oppressively or arbitrarily; it must be exercised purely for the public good, and that in a manner not destructive of the adverse interest; for, great as is the police power of a state, everything done under its name can not be justified, but must be a legitimate, necessary act, and must pass under judicial review." (32)

**§231 Limits of State Officers' Powers.**—"The attempt of a state officer to enforce an unconstitutional statute is a proceeding without authority of, and does not affect, the State in its sovereign or governmental capacity. It is an illegal act and the officer is stripped of his official character and is subjected in his person to the consequences of his individual conduct. The State has no power to impart to its officer immunity from responsibility to the supreme authority of the United States." (472)

**§232 Abuse of Police Power.**—"A large discretion is necessarily vested in the legislature to determine, not only what the interests of the public require, but what measures are necessary for the protection of such interests. To justify the state in thus interposing its authority in behalf of the public, it must appear, first, that the interests of the public generally, as distinguished from those of a particular class, require such interference; and second, that the means are reasonably necessary for the accomplishment of the purpose, and not unduly oppressive upon individuals. The legislature may not, under guise of protecting public interests, arbitrarily interfere with private business, or impose unusual and unnecessary restrictions upon lawful occupations. In other words, its determination of what is a proper exercise of the police power is not final or conclusive, but is subject to the supervision of the courts." (387)

**§233 Police Power Limited By Federal Constitution.**—"The police power must be exercised in subordination to the provisions of the Federal Constitution. If, in the assumed exercise of its police power, the legislature of a State directly and plainly violates a provision of the Constitution of the United States, such legislation would be void." (439)

**§234 Delegated Power.**—"A by-law or ordinance of a municipal corporation may be such an exercise of legislative power delegated

by the legislature to the corporation as a political subdivision of the State, having all the force of law within the limits of the municipality, that it may properly be considered as a law within the meaning of the Constitution of the United States." (457)

**§235 What Is a Vested Right?**—"This is a right vested in a citizen to do certain actions, or to possess certain things, according to the law of the land." (281) "A vested right is an immediate fixed right of present or future enjoyment." (408)

**§236 Vested Rights Must Be Protected.**—"Every statute which takes away or impairs vested rights acquired under existing laws, or creates a new obligation, imposes a new duty, or attaches a new disability in respect to transactions or considerations already past, must be deemed retrospective, and hence void." (281)

**§237 Contract Not Limited By Life of Corporation.**—"The mere fact that a contract may extend beyond the term of the life of a corporation does not destroy it." (494)

**§238 Tests for Exclusive Grants.**—Since "an exclusive right to enjoy a franchise is never presumed, and every reasonable doubt must be resolved adversely," (410) an exclusive grant to be valid must comply with all of the following four requirements:

1. Must not be contrary to the Constitution.
2. Must be authorized by valid legislation. In the case of municipal grants, the power to confer exclusive grants must be clearly shown in the legislation granting the municipal charter.
3. Must clearly show a contract between the State and the grantee. There are no implied powers either for granting or interpreting such grants. There must be a legal contract. "If there is no contract, there is nothing in the grant on which the Constitution can act. Consequently, the first inquiry in this class of cases always is, whether a contract has in fact been entered into." (333)
4. Must have vested rights. "Until some expenditure has been made upon its faith, the charter or grant may be repealed or altered, since until then there is no completed contract or vested property." (32 citing 404)

**§239 Classes of Exclusive Grants.**—Exclusive charter, franchise or other grants are divided into two clearly defined classes:

First: Those not having any specific contractual relation with the state regarding the exclusive features, these apparent exclusive features being secured by virtue of the protection of state laws.

Second: Those having a specific contract with the state governing the exclusive features and standing all four of the prescribed tests.

In the first class the repealing of the legislation,—which may be done at any time—would of course destroy the exclusive features of the grant. In regard to this class, the doctrine that there is no valid contract and therefore there can be no constitutional protection was maintained in (366) and (452). Hence the exclusive features of this class of grants are valueless.

The validity of the second class has been established by many decisions. "The constitutional right of one legislature to grant corporate privileges and franchises, so as to bind and conclude a succeeding one, and that an act of incorporation is a contract between the state and stockholders, is settled by an unbroken course of decisions in federal and state courts. All courts are estopped at this day from questioning the doctrine. The security of property rests upon it, and every successful enterprise is undertaken in the unshaken belief that it will never be forsaken." (283, 300, 344, 406)

In (405) this doctrine is called "a canon of American jurisprudence," and in (332) it is said "to have become so imbedded in jurisprudence of the United States as to make it to all intents and purposes a part of the Constitution itself."

**§240 States Cannot Tax Federal Franchise.**—A franchise granted by congress cannot be destroyed, abridged or burdened by any State. Hence, States cannot tax federal franchises. (357)

**§241 Utilities May Cease Giving Service.**—"There are sufficient dicta in the books to the effect that a chartered company, even if possessing special privileges, may withdraw from its enterprise altogether." (54)

**§242 Who May Surrender Governmental Power.**—"The surrender, by contract, of a power of government, tho in certain well-defined cases it may be made by legislative authority, is a very grave act, and the surrender itself as well as the authority to make it, must be closely scrutinized. No other body than the supreme legislature has the authority to make such a surrender, unless the authority is clearly delegated for that purpose." (479)

**§243 When Rate Regulating Power May Be Suspended.**—"The State may authorize one of its municipal corporations to establish by an inviolable contract the rates to be charged by a Utility for a definite term, not grossly unreasonable in point of time, and the effect of such a contract is to suspend, during the life of the contract, the governmental power of fixing and regulating rates." (460, 471, 479)

When rates are fixed by ordinance for a stated time, and there is no reservation of a right to alter the rates during such time, and

the ordinance is duly accepted and complied with by a Utility, binding contractual relations are established between the Utility and the governing power, and such governing power has exhausted its powers and is precluded from subsequently changing such rates during the period specified in the ordinance. (467)

**§244 Unprofitable Service Extensions Need Not Be Made By Utility.**—"The obligation of a Utility to supply a dwelling with service, and for that purpose to lay down a supply pipe and set a meter, is subject to the limitation that there shall exist a reasonable expectation that the consumption will warrant the necessary preliminary expenditure." (583) The same doctrine was laid down in (734).

"A city ordinance, requiring a Utility to install and furnish service on demand from any citizen without reference to the distance of such installation from the constructed lines of the Utility, upon the deposit by the applicant of the estimated cost of one month's service, and in certain cases without any deposit on the giving of a bond, and not to discontinue such service except on request, or by consent of the city council, regardless of whether the rates were paid when due, is void as unreasonable and as taking the Company's property without due process of law for the private use of another." (561)

"A municipal corporation has no power, nor can power be conferred on it by statute, to enact an ordinance, the effect of which will be to take the property of a Utility for a private use." (561)

The law is good if a man use it lawfully.
—St. Paul.

# Chapter 6

## REQUIREMENTS OF REGULATION

**§245 Co-Ordination of Regulation Requirements.**—This is shown in Fig. 18, p. 87.

**§246 Regulation Must Be Just.**—The power to do an act does not establish the right to do it, and governmental might is not necessarily constitutional right. "Justice and power must be brought together, so that what is just may be powerful and what is powerful may be just." As aptly stated by the late Justice Brewer, "The wisdom of government is not in protecting power, but weakness; not so much in sustaining the rules, as in securing the rights of the ruled. The true end of government is protection to the individual; the majority can take care of itself."

"No legislature or commission, acting under the authority of the legislature, can arbitrarily and without regard to justice and right establish a tariff of rates which is so unreasonable as to practically destroy the value of property of persons engaged in business." (364)

**§247 Conservatism Mandatory.**—The necessity of conservatism in legislation is clearly indicated in the following: "The forms of law and the machinery of government with all their right and power must, in their actual workings, stop on the hither side of the unnecessary and uncompensating taking or destruction of any private property legally acquired and legally held." (394)

**§248 Regulation Must Be Constitutional.**—"If the company is deprived of the power of charging reasonable rates for the use of its property and such deprivation takes place in the absence of any investigation by judicial machinery, it is deprived of the lawful use of its property in violation of the Constitution of the United States." (363)

"Altho under governmental control, that control must be exercised with due regard to constitutional guarantees for the protection of its property." (440)

**§249 Regulation Must Be Based On Predetermined Facts.**—"He that judges without informing himself to the utmost that he is capable, cannot acquit himself of judging amiss." Rate prescribing legislation must be based on predetermined facts; a careful investigation of circumstances is a condition precedent to equitable rate

# FIG. 18
# REQUIREMENTS OF UTILITY REGULATION

- I REGULATION MUST BE
  - 1 JUST
  - 2 CONSERATIVE
  - 3 CONSTITUTIONAL
  - 4 BASED ON
    - PREDETERMINED FACTS
    - VALUE THAT
      - FAIR
      - CONSIDERS PRODUCTIVENESS
      - INCLUDES INTANGIBLE PROPERTY
    - JUST COMPENSATION
    - PUBLIC GOOD
  - 5 REASONABLE
- II REGULATION MUST NOT
  - 1 IGNORE PUBLIC'S INTEREST IN FAIR RATE
  - 2 DISCRIMINATE
  - 3 BE ARBITRARY
  - 4 CONFISCATE
  - 5 BE WRONGFULLY ADMINISTERED
  - 6 CONTAIN INTIMIDATING PENALTIES
  - 7 NEEDLESSLY INTERFERE
- III RATE MAKING IS LEGISLATIVE FUNCTION
- IV CORRECTNESS OF RATE CANNOT BE DETERMINED BY
  - 1 PROFITS
  - 2 GENERAL RULES
  - 3 COMPANY ACTION
  - 4 GROSS RECEIPTS
  - 5 CAPITALIZATION
    - BONDED
    - FICTITIOUS
  - 6 MANAGEMENT RESULTS
  - 7 INTER OR INTRA STATE BUSINESS
- V LEGISLATION
  - 1 DISTINCTION BETWEEN JUDICIAL & LEGISLATIVE ACTS
  - 2 WHEN MAY BE COMBINED WITH JUDICIAL POWERS
  - 3 LIMITED TO MAXIMUM RATES
  - 4 MUST BE INTERPRETED RATIONALLY
  - 5 ABSURD CONSTRUCTION PRECLUDED
  - 6 NEVER CONCLUSIVE
  - 7 CANNOT
    - PRECLUDE COURT REVIEW
    - IMPAIR LEGAL CONTRACT
  - 8 STATES CANNOT STOP INTER STATE TRANSPORTATION OF THEIR OWN NATURAL RESOURCES
  - 9 EFFECT IS TEST FOR VALIDITY
- VI FRANCHISE
  - 1 STATUS
  - 2 CONSIDERATION
  - 3 NOT COMMON RIGHTS
  - 4 OBLIGATIONS
- VII FEDERAL CONSTITUTION CONTROLS
- VIII COMMERCE
  - 1 INTERSTATE
    - FEDERAL POWER
      - GENERAL
      - EXTENT
    - STATES CANNOT
      - BURDEN
      - DISCRIMINATE AGAINST
  - 2 INTRASTATE
    - LIMIT OF STATE POWERS
    - WHEN FEDERAL POWER APPLIES

determination. "It is not a matter of guess work or of arbitrarily fixing all rates. When the constitution provides for the fixing of rates or compensation, it means reasonable rates and just compensation." (444)

"The very use of the term 'regulation' implies that an investigation shall be made; that an opportunity to present the facts shall be furnished; that, when the facts are established, they shall, by the regulating power, be given due consideration; and that such action as shall be taken in view of these facts, thus ascertained, shall be just and reasonable." (513)

**§250 Basis Is Fair Value of Property.**—"What the company is entitled to ask is a fair return upon the value of that which it employs for the public convenience, and it may not be required to use its property for the benefit of the public without receiving just compensation for the services rendered by it." (433)

**§251 Productiveness Determines Value.**—"The value of property, generally speaking, is determined by its productiveness—the profits which its use brings to the owner. Various elements enter into this matter of value. The value is not determined by the mere cost of construction, but more by what the completed structure brings in the way of earnings to its owner." (379)

**§252 Intangible Property.**—"Just compensation requires payment for the franchise, as well as for the value of the tangible property." (380)

**§253 Just Compensation Mandatory.**—"The corporation may not be required to use its property for the benefit of the public without receiving just compensation for the services rendered by it." (433)

"Under pretence of regulating fares and freights, the State cannot require a railroad corporation to carry persons or property without reward, neither can it do that which in law amounts to the taking of private property without just compensation." (426)

"If the company is deprived of the power of charging reasonable rates for the use of its property, it is deprived of the lawful use of its property." (426)

The regulating power of the State is not one "to destroy or a power to compel the doing of services without reward." (373)

"In every constitution is the guarantee against the taking of private property for public purposes without just compensation." (427)

"A state enactment, or regulations made under the enactment, establishing rates that will not admit the company earning such compensation as, under all the circumstances, is just to it and to the public" is unconstitutional. (428)

**§254 Motive Must Be Public Good.**—State interference is clearly limited to legislation for the public good. "To justify the State in interposing its authority in behalf of the public, it must appear, first, that the interests of the public generally, as distinguished from those of a particular class, require such interference; and second, that the means are reasonably necessary for the accomplishment of the purpose and not unduly oppressive upon individuals." (387)

**§255 Reasonableness of Ordinances.**—It must be regarded as established beyond question that the power to regulate rates is subject to the following limitations:

1. "That there is reasonable need on the part of the public, considering the nature and extent of the service, of lower rates and better terms than those existing." (516)

2. "That the rates and terms fixed by ordinance are not clearly unreasonable in view of all the conditions." (516)

3. "Neither of these considerations is independent of the other and, altho the public interest is of the first importance, the test is not what is desirable upon the part of either, but what is reasonable in respect to the rights of both." (516)

4. "What the company is entitled to ask is a fair return upon the value of what it employs for the public convenience." (516)

5. "What the public is entitled to demand is that no more be exacted from it than the service is reasonably worth." (516)

**§256 Public Interested In Fair Rate.**—It is evident that the enforcement of an inadequate rate will decrease the income of the server. As a result, the quality of the service rendered will be impaired, and the public will suffer with the server. Hence, "the rights of the public are ignored if rates are exacted without reference to the fair value of the property used for the public, or the fair value of the services rendered." (431)

**§257 Must Not Discriminate.**—"The inhibition that no state shall deprive any person within its jurisdiction of the equal protection of the laws, was designed to prevent any person or class of persons from being singled out as a special subject for discriminating and hostile legislation." (354)

**§258 Must Not Be Arbitrary.**—"The legislature may not, under a guise of protecting the public interests, arbitrarily interfere with private business or impose unusual or unnecessary restrictions upon lawful occupations." (387)

**§259 Must Not Confiscate.**—"From what has been said, it is not to be inferred that this power of limitation or regulation is itself

without limit. This power to regulate is not a power to destroy, and limitation is not the equivalent of confiscation." (347)

**§260 Must Not Be Wrongfully Administered.**—"A valid law may be wrongfully administered by officers of the State, so as to make such administration an illegal burden and exaction upon the individual. They may go beyond the powers thereby conferred and, when they do so, the fact that they are assuming to act under a valid law will not oust the courts of jurisdiction to restrain their excessive and illegal acts." (390)

**§261 Intimidating Penalties Void.**—"When the legislature, in an effort to prevent any inquiry of the validity of a particular statute, so burdens any challenge thereof in the courts that the party affected is necessarily constrained to submit rather than take the chances of the penalties imposed, then it becomes a serious question whether the party is not deprived of the equal protection of the laws." (459)

"The provisions of acts relating to the enforcement of rates, by imposing such enormous fines and possible imprisonment as a result of an unsuccessful effort to test the validity of the laws themselves, are unconstitutional on their face, without regard to the question of the sufficiency of those rates." (475)

**§262 Regulation Must Not Needlessly Interfere.**—"While the power of regulation exists, it is also to be remembered that the legislature cannot, under the guise of regulation, interfere with the proper conduct of the business of the Utility in matters which do not fairly belong to the domain of reasonable regulation." (438)

**§263 Rate-Making Is Legislative Function.**—"The function of rate-making is purely legislative in its character, and this is true, whether it is exercised directly by the legislature itself or by some subordinate or administrative body to whom the power of fixing rates in detail has been delegated. The completed act derives its authority from the legislature, and must be regarded as an exercise of the legislative power." (481)

**§264 Profits.**—There are no legal restrictions as to the aggregate profits on the whole business. "The question is, not how much he makes out of his business, but whether or not any particular transaction is an unreasonable exaction for the services rendered." Nor is it to be expected that the profits of a small patron should be the same as on the large ones. "It by no means follows that the companies are entitled to earn the same percentage of profits upon all classes of freight carried. We do not think it beyond the power of the State Commission to reduce the rate upon a particular article, providing the companies earn a fair proportion on the entire business." (461)

**§265 General Rules.**—There can be no general rules to fit all cases. Nor would a uniform rate for various companies operating under widely different operating conditions be equitable. "Each case must depend upon its special facts." (413)

**§266 Company Action No Criterion.**—"What the company may choose voluntarily to do furnishes no criterion for the measurement of the power of a legislature. Persons may voluntarily contract to do what no legislature would have the right to compel them to do. Nor does it furnish a standard by which to measure the reasonableness of the matter exacted by the legislature. The action of the company upon its own volition, purely as a matter of internal administration, and in regard to the details of its business, which it has a right to change at any moment, furnishes no argument for the existence of a power in a legislature to pass a statute in relation to the same business imposing additional burdens upon the company." (442)

**§267 Gross Receipts No Criterion.**—"The amount of gross receipts from any business does not of itself determine whether such business is profitable or not. The question of expenses incurred in producing those receipts must always be taken into account." (450)

**§268 Bonded Indebtedness Not Controlling.**—"The property may have cost more than it ought to have cost, and its outstanding bonds for money borrowed, and which went into the plant, may be in excess of the real value of the property, so that it cannot be said that the amount of such bonds should in every case control the question, altho it may be an element in the inquiry as to what is, all the circumstances considered, just both to the company and to the public." (445)

**§269 Fictitious Capitalization No Criterion.**—"If a corporation has bonded its property for an amount that exceeds its fair value, or if its capitalization is largely fictitious, it may not impose upon the public the burden of such increased rates as may be required for the purpose of realizing profits upon such excessive valuation or fictitious capitalization. The apparent value of the property and franchises used, as represented by its stocks, bonds and obligations, is not alone to be considered when determining the rates that may reasonably be charged." (431)

"The public cannot properly be subjected to unreasonable rates simply that stockholders may earn dividends. If a corporation cannot maintain such a highway and earn dividends for stockholders, it is a misfortune for it and them which the constitution does not require to be remedied by imposing unjust burdens upon the public." (432)

**§270 Management Results.**—Excessive promotion costs, poor judgment in management or construction, and excessive capitalization will not be recognized as conditions necessitating a high rate. "Original costs may have been too great, mistakes of construction, even tho honest, may have been made which necessarily enhance the cost; more property may have been acquired than necessary for the purpose intended." (466)

**§271 Inter- and Intrastate Business.**—"The reasonableness or unreasonableness of rates prescribed by a State for the transportation of persons and property wholly within its limits must be determined without reference to the profits derived from interstate business. The State cannot justify unreasonably low rates for domestic transportation, considered alone, upon the ground that the interstate profits are large. Nor can a carrier justify unreasonably high rates on domestic business upon the ground that it must meet losses on the interstate business." (430)

**§272 Distinction Between Judicial and Legislative Acts.**—"This is clearly defined. The judiciary determines what the law is, and what the rights of parties are with reference to transactions already had; the legislature prescribes what the law shall be in future cases arising under it." (327)

"A judicial inquiry investigates, declares, and enforces liabilities as they stand on present or past facts, and under laws supposed already to exist. That is its purpose and end. Legislation, on the other hand, looks to the future, and changes existing conditions by making a new rule to be applied thereafter to all or some part of those subject to its power." (478)

**§273 When Legislative and Judicial Functions May Be Combined.**—"So far as the Federal Constitution is concerned, a State may, by constitutional provision, unite legislative and judicial powers in the same body." (477)

**§274 Limited to Maximum Rates.**—The power of the legislature is exhausted in fixing a maximum rate which will protect the public from the hardships of excessive charges, and an attempt to regulate further is unconstitutional and void. "The legislature has the power to declare a general law upon the subject of rates beyond which the company cannot go, but within which it is at liberty to conduct its work in such a manner as may seem to it best suited for its prosperity and success." (441)

**§275 Legislation Must Be Interpreted Rationally.**—"It is a familiar rule that a thing may be within the letter of the statute and yet not within the statute, because not within its spirit, nor

within the intention of its makers. This has often been asserted, and the reports are full of cases illustrating its application. This is not the substitution of the will of the judge for that of the legislator, for frequently words of general meaning are used in a statute, words broad enough to include an act in question, and yet a consideration of the whole legislation, or of the circumstances surrounding its enactment, or of the absurd results which follow from giving such broad meaning to the words, makes it unreasonable to believe that the legislator intended to include the particular act." (372)

**§276 Absurd Construction of Legislation Precluded.**—"If a literal construction of the words of a statute be absurd, the act must be so construed as to avoid the absurdity. The court must restrain the words. The object designed to be reached by the act must limit and control the literal import of the terms and phrases employed." (372)

"All laws should receive a sensible construction. General terms should be so limited in their application as not to lead to injustice, oppression or an absurd consequence. The reason of the law should prevail over its letter." (372)

**§277 Legislative Action Never Conclusive.**—"The idea that any legislature, State or Federal, can conclusively determine for the people and for the courts that what it enacts in the form of law, or what it authorizes its agents to do, is consistent with the fundamental law, is in opposition to the theory of our institutions. The duty rests upon all courts, Federal and State, when their jurisdiction is properly invoked, to see that no right secured by the supreme law of the land is impaired or destroyed by legislation." (429)

"The legislature is presumed to act with full knowledge of the facts upon which its legislation is based, but when it is assumed from that that its judgment upon the facts is not subject to investigation, the inference is carried too far." (449)

**§278 Court Review Cannot Be Precluded.**—An enactment, which makes any rate-prescribing legislation final and conclusive as to what are equal and reasonable charges, and under which there can be no judicial inquiry as to the reasonableness of such rates, is unconstitutional. (362)

**§279 Legal Contract Cannot Be Impaired.**—"The sound and true rule is that, if the contract, when made, was valid by the laws of the state as then expounded by all departments of the government, its validity and obligation cannot be impaired by any subsequent action of legislation or decision of its courts altering the construction of this law." (299)

**§280 States Cannot Stop Interstate Transportation of Their Own Natural Resources.**—"When a State recognizes an article to be a subject of interstate commerce, it cannot prohibit that article from being the subject of interstate commerce, and corporations engaged in interstate commerce cannot be excluded from transporting from a state oil and gas produced therein and actually reduced to possession." (507)

**§281 Effect Is Test for Validity of Legislation.**—"According to well-settled rules of statutory construction, the validity of a statute, whatever its language, must be determined by its effect or operation, as manifested by the natural and reasonable meaning of the words employed." (496)

"The effect, and neither the terms nor the purpose, of state regulations determines whether they substantially burden, or only incidentally or remotely affect, interstate commerce. This is a judicial question which each court must decide on its own responsibility on the special facts of the case before it, and in the decision of which it must obey the constitution, rather than the law-making department of the government." (547)

**§282 Status of Franchise.**—"A franchise is property, and subject to all the rules of property." (291)

**§283 Franchise Consideration.**—The benefit may constitute the sole consideration for the grant of a franchise by a state. (283)

"The fact that a franchise has been acquired from the municipality by gift or without adequate compensation may evidence lack of foresight, or something worse, on the part of the municipal government, but it can have no effect on the value. The franchise, however acquired, must be considered." (527)

**§284 Franchises Not Common Rights.**—"Franchises are special privileges conferred by the government on individuals, and do not belong to the citizens of the country generally of common right." (302)

**§285 Obligation With Franchise Acceptance.**—"The acceptance of the franchise implies a submission to the conditions, without which the franchise could not have been obtained." (389)

**§286 Federal Constitution Controls.**—"The government of the United States, tho limited in its powers, is supreme; and its laws, when made in pursuance of the constitution, form the supreme law of the land, anything in the constitution or laws of any state to the contrary notwithstanding." (282)

"Congress is authorized to adopt corrective legislation,—that is, such as may be necessary and proper for counteracting such acts

and proceedings or laws as the states may adopt or enforce, and which by the 14th Amendment they are prohibited from making or enforcing." (336)

**§287 General Nature of Federal Power Over Commerce.**—"The power to regulate commerce is general, and has no limitations but such as are prescribed in the Constitution itself." (288)

**§288 Extent of Federal Power Over Commerce.**—"The United States may exercise the power to regulate commerce between the states to its utmost extent, and may use all means requisite to its complete exercise, and no state by virtue of any power it possesses, either under the name of the police power or under any other name, may lawfully restrict or infringe this grant." (548)

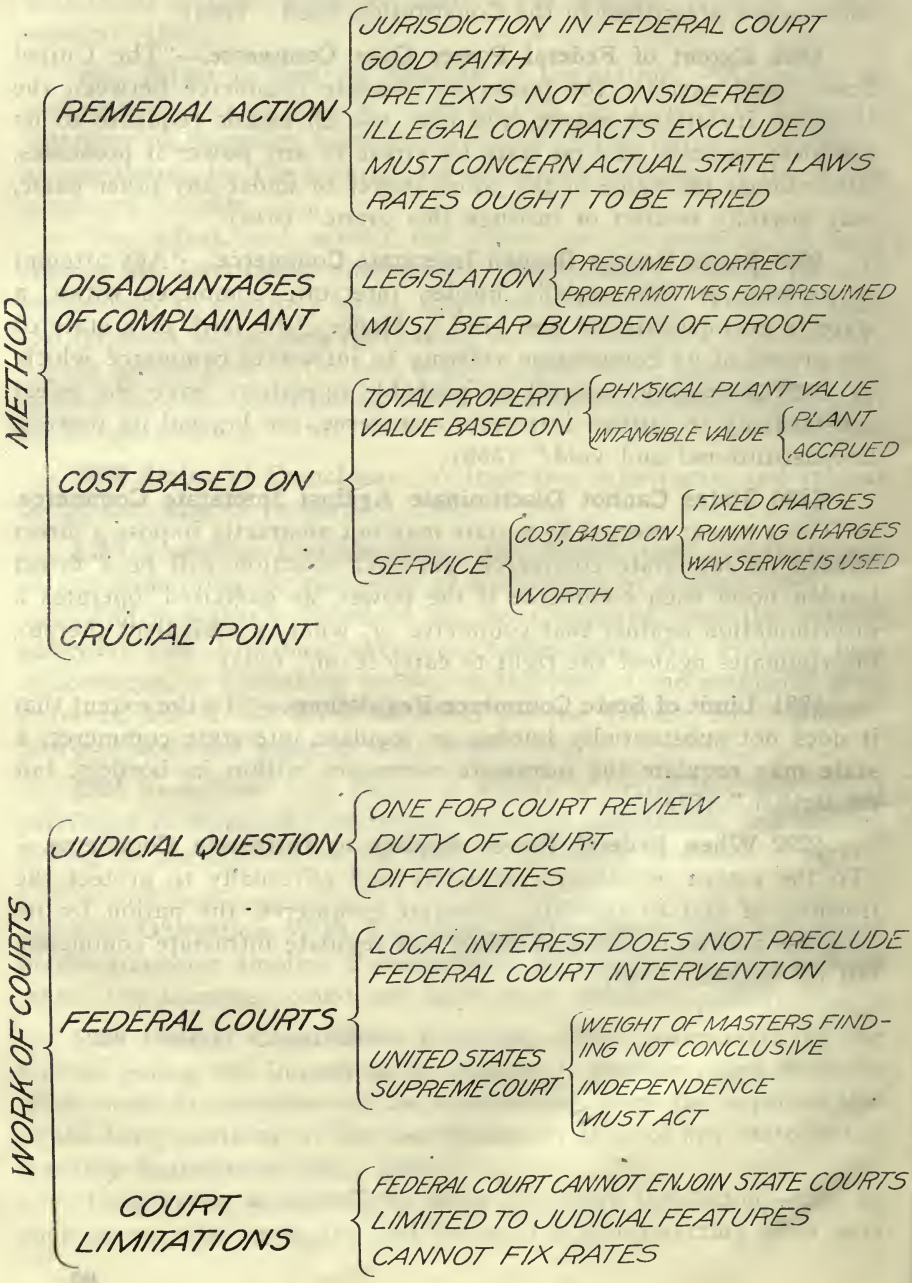
**§289 States Cannot Burden Interstate Commerce.**—"Any attempt to prohibit or substantially burden interstate commerce within a state is unconstitutional and void." Hence, "the laws of a state or the orders of its commission relating to intrastate commerce which, by their necessary, natural or probable operation, have the effect substantially to burden interstate commerce, are beyond its powers, unconstitutional and void." (550)

**§290 States Cannot Discriminate Against Interstate Commerce.**—"Tho a power exerted by a state may not abstractly impose a direct burden on interstate commerce, yet such exertion will be a direct burden upon such commerce if the power, as exercised, operates a discrimination against that commerce or, what is equivalent thereto, discriminates against the right to carry it on." (495)

**§291 Limit of State Commerce Regulations.**—"To the extent that it does not substantially burden or regulate interstate commerce, a state may regulate the intrastate commerce within its borders, but no farther." (549)

**§292 When Federal Power Applies to Intrastate Commerce.**—"To the extent necessary completely and effectually to protect the freedom of and to regulate interstate commerce, the nation by its congress and its courts may affect and regulate intrastate commerce, but no farther." (549)

# FIG. 19
# RELIEF FROM OPPRESSIVE REGULATION



Your plea is good
But still I say, Beware;
Laws are explained by men,
So have a care.
—Pope.

# Chapter 7

## RELIEF FROM OPPRESSIVE LEGISLATION

**§293 Jurisdiction.**—Since the question of rate regulation involves a constitutional problem, thereby making it a federal question, it obviously places it in the jurisdiction of the United States courts. This is fortunate, in that it removes the case from local influences and produces conditions which are more favorable for the development of justice and equity. However, "the jurisdiction of the federal courts is a limited jurisdiction, depending either upon the existence of a federal question or the diverse citizenship of the parties." (383). For co-ordination of relief steps see Fig. 19, p. 96.

**§294 Good Faith.**—In order to start relief from oppressive legislation, it is necessary only to allege in good faith that the rate in question is confiscatory. The outcome of the case has no bearing on this preliminary step. "Jurisdiction depends upon the allegations of the bill and not upon the facts as they subsequently turned out to be." (418)

**§295 Pretexts Not Considered.**—"When a suit does not really and substantially involve a dispute or controversy as to the effect or construction of the constitution, upon the determination of which the result depends, then it is not a suit arising under the constitution." (388)

"The judicial power extends to all cases in law and equity arising under the constitution, but these are cases actually and not potentially arising, and jurisdiction cannot be assumed on mere hypotheses." (388)

"The administration of justice ought not to be interfered with on mere pretexts." (403)

**§296 Illegal Contracts Excluded.**—"The 14th Amendment does not guarantee the citizen the right to make within his State, either directly or indirectly, a contract, the making whereof is constitutionally forbidden by the State." (398)

**§297 Must Concern Actual State Laws.**—"A municipal ordinance, not passed under supposed legislative authority, cannot be regarded

as a law of the State within the meaning of the constitutional prohibition against State laws impairing the obligation of contracts." (376)

**§298 Rates Ought to Be Tried.**—"The case must be a clear one before the courts ought to be asked to interfere with rates, especially before there has been an actual experience of the practical result of such rates." (487)

**§299 Legislation Presumed Correct.**—"An act of the legislature is not to be declared void unless the violation of the constitution is so manifest as to leave no room for reasonable doubt." (303)

"It is not on slight implication and vague conjecture that the legislature is to be pronounced to have transcended its powers and its acts to be considered void. The opposition between the constitution and the law should be such that the judge feels a clear and strong conviction of their incompatibility with each other. It is incumbent, therefore, upon those who affirm the unconstitutionality of an act, to show clearly that it is so. It is not sufficient to raise a doubt." (303)

"Every statute is presumed to be constitutional. The courts ought not to declare one to be unconstitutional unless it is clearly so. If there is doubt, the expressed will of the legislature should be sustained." (308)

**§300 Proper Motives of Legislators Presumed.**—"Courts will not inquire into the motives of legislators in enacting laws, except as they are disclosed on the face of acts, or be inferable from their operation. The motives of legislators, considered as to the purposes they had in view, will always be presumed to be to accomplish that which follows as the natural and reasonable effects of their enactments." (342)

**§301 Burden of Proof On Complainant.**—"Upon any company seeking to challenge the validity of legislation rests the burden of proof that it infringes the constitutional guarantee of protection to property. The case must be clear on behalf of the company or the legislation of State must be upheld. Such being unquestionably the law, it is obviously of the utmost importance that the facts shall be clearly and accurately found, and that those facts shall sustain the conclusion reached." (449)

**§302 Value of Property or Service.**—This must be determined by applying the principles laid down in Chapters 3, 11, 12 and 13.

**§303 Crucial Point.**—The establishment of the true cost and worth of the Utility service in question is the crucial point of all relief legislation. No new principle of law is involved since the dicta laid down in Chapters 4, 5, 6 and 7 cover essentially every legal problem that will arise.

**§304 Court Review.**—"The question of the reasonableness of a rate of charge, involving as it does the element of reasonableness, both as regards the company and as regards the public, is eminently a question for judicial investigation, requiring the process of law for its determination." (363)

"It is within the scope of judicial power to restrain anything which, in the form of a regulation of freights, operates to deny the owners of property invested in the business of transportation that equal protection which is the constitutional right of all owners of other property." (400)

"There is an ultimate remedy for relief against oppressive legislation, and especially in the courts of the United States, where the tariff of rates established either by the legislature or by the commission is such as to deprive a party of his property without due process of law." (364)

**§305 Duty of Courts.**—The duty of the courts is clearly established. "There can be no doubt of their power and duty to inquire whether a body of rates prescribed by a legislature or a commission is unjust and unreasonable and such as to work a practical destruction to rights and property, and if found so to be, to restrain its operation." (393)

"The duty rests upon all courts, Federal and State, when their jurisdiction is properly invoked, to see to it that no right secured by the law of the land is impaired or destroyed by legislation." (425)

"It has always been a part of the judicial function to determine whether the act of one party—whether that party be a single individual, an organized body, or the public as a whole—operates to divest the other party of any rights of person or property." (394)

**§306 Difficulties.**—"Few cases are more difficult or perplexing than those which involve an inquiry whether the rates prescribed by a state legislature for the carriage of passengers and freight are unreasonable. Yet the difficulty affords no excuse for a failure to examine and solve the questions involved." (448)

"Difficult as are the questions involved in these cases, burdensome as is the labor which they cast upon the courts, no tribunal can hesitate to respond to the duty of inquiry and protection cast upon it by the Constitution." (448)

**§307 Local Interest Does Not Preclude Federal Intervention.**—"When a Federal court is properly appealed to in a case over which it has by law jurisdiction, it is its duty to take such jurisdiction. That the case may be one of local interest only is entirely immaterial, so long as a question is involved which by law brings the case within the jurisdiction of a Federal court." (486)

"The right of a party plaintiff to choose a Federal court where there is a choice cannot be properly denied." (486)

**§308 Weight of Master's Finding Limited.**—"In view of the character of the judicial power invoked in rate regulation cases, it is not tolerable that its exercise should rest securely upon the findings of a master, even though they be confirmed by the trial court. The power is best safe-guarded against abuse by preserving to the U. S. Supreme Court complete freedom in dealing with the facts of each case." (481)

**§309 Independence of United States Supreme Court.**—In all rate regulation or valuation cases, the U. S. Supreme Court "will not fetter its discretion or judgment by any artificial rule as to the weight of the master's findings, however useful and well settled these rules may be in ordinary litigation." (481)

**§310 United States Supreme Court Must Act.**—The Court's duty was clearly expressed by Chief Justice Marshall:

"The judiciary cannot, as the legislature may, avoid a measure because it approaches the confines of the Constitution. We cannot pass it by because it is doubtful. With whatever doubts, with whatever difficulties a case may be attended, we must decide it, if it be brought before us. Questions may occur which we would gladly avoid, but we cannot avoid them. All we can do is to exercise our best judgment, and conscientiously perform our duty." (286, 474)

**§311 Federal Court May Not Enjoin State Court.**—"An injunction by a Federal court against a State court would violate the whole scheme of this government, and it does not follow that, because an individual may be enjoined from doing certain things, a court may be similarly enjoined." (473)

**§312 Limitation of Court.**—"A court may enforce in its own appropriate way the specific performance of an existing legal obligation arising out of contract law or usage, but it cannot create the obligation." (338)

**§313 Court Cannot Fix Rates.**—The power of the courts is rigidly limited to the judicial side of the controversy. "The extent of judicial interference is protection against unreasonable rates." (371) "The courts are not authorized to revise or change the body of rates imposed by a legislature or a commission; they do not determine whether one rate is preferable to another." (393)

Hence, it is evident that in securing relief from oppressive rates, the court action is limited simply to annulling the rates in question. New rates may be established only by the legislature.

* * * The wonderful one-hoss shay,
That was built in such a logical way,
It ran a hundred years to a day,
Then there were traces of age in the one-hoss shay
A general flavor of mild decay,
And then of a sudden * * *
It went to pieces all at once.

—Holmes.

# Chapter 8

## DEPRECIATION

**§314 Recognition of Depreciation a Duty.**—"A sufficient amount should be allowed from the earnings of a Utility to make good the depreciation of the plant and replace the deteriorated portions thereof, when they become so impaired that they can no longer be made useful by repair." (600)

"An ordinance fixing the compensation for perishable property devoted to public use, which fails to make any provision for depreciation and keeping the original investment intact, is unjust to the owner." (525)

"Before coming to the question of profit at all, the company is entitled to earn a sufficient sum annually to provide, not only for current repairs, but for making good the depreciation and replacing the parts of the property when they come to the end of their life. The company is not bound to see its property gradually waste, without making provision out of earnings for its replacement. It is entitled to see that from earnings the value of the property invested is kept unimpaired, so that at the end of any given term of years the original investment remains as it was at the beginning. It is not only the right of the company to make such a provision, but it is its duty to its bond and stockholders, and, in the case of a Utility at least, its plain duty to the public." (482)

**§315 Failure to Provide for Depreciation Is Fault of Utility.**—"If a company fails to exact sufficient returns to keep the investment unimpaired, whether this is the result of unwarranted dividends upon over-issues of securities, or of omission to exact proper prices for the output, the fault is its own. When, therefore, a public regulation of its prices comes under question, the true value of the property then employed for the purpose of earning a return cannot be enhanced by a consideration of the errors in management which have been committed in the past." (482)

**§316 Depreciation Allowance Is for Past Obligations.**—"It is a misconception to describe the annual provision for depreciation as a provision for future renewals, as tho it has reference to the future. The annual provision for depreciation has nothing to do with the future but relates solely to the past. It is a replacement of capital in respect to past capital outlay expired in the process of carrying on the business." (17)

**§317 Species of Depreciation.**—These are shown in their logical order in Fig. 20, p. 103.

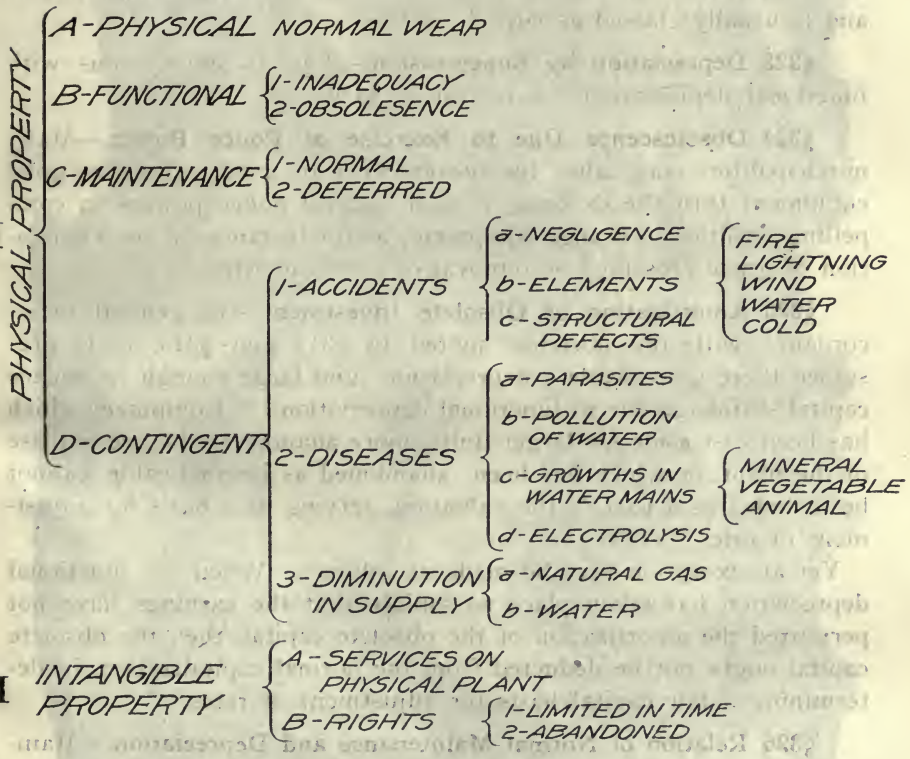
**§318 Normal Wear.**—Depreciation on equipment begins in many cases even before the work is completed, and continues without interruption—in spite of all honest effort and the most elaborate maintenance—until the equipment becomes useless or is replaced. The normal wear in a properly maintained plant will not be conspicuous, and in most cases not even superficially noticeable, for the major part of its normal life. Yet this lessening of worth is an omnipresent, inexorable reality that will be going on constantly until the inevitable end is reached, like the final fate of the one-hoss shay.

**§319 Commercial Limitation of Life.**—"Few parts of physical property in use ever become completely worn out; after a certain amount of wear, a point is reached at which good engineering requires their replacement; they may be still further used, but only at the cost of economy and safety. After a given number of years, the expense of maintenance on almost any piece of property will become so large that it is more economical to abandon than to replace it." (97)

**§320 Functional Depreciation.**—"The determination of depreciation due to inadequacy and obsolescence is a particularly delicate matter, it depends so largely on local conditions and especially upon individual judgment. Inadequacy and obsolescence usually develop so quickly that very frequently the property in question becomes obsolete within a few months, and has depreciated to scrap value almost as soon as these classes of depreciation are recognized,—a space of time entirely too brief in which to apply ordinary methods of offsetting depreciation. An attempt to prognosticate on inadequacy and obsolescence over considerable periods in advance of their appearance is little more than a guess, even by the most experienced." (97)

**§321 Inadequacy.**—"This arises from increased demands of service so as to render the property in use inconvenient or uneconomical for continuance of operation, altho in every way capable of performing the service for which it was installed." (97)

# FIG. 20
# SPECIES OF DEPRECIATION THAT MUST BE RECKONED WITH TO KEEP ORIGINAL INVESTMENT INTACT



"Inadequacy may and does take place without regard to the length of time the property has been in use or to the amount of service rendered." (97)

**§322 Obsolescence.**—This is "the depreciation due to the development of something newer and either more economical or more of a fad. It may necessitate the abandonment of a property long before it is worn out, and, in many cases, arises largely from demand of the public." (97)

"Equipments that at any given time are regarded as adequate and the most modern are in a short time, because of new inventions and improvements, inadequate and obsolete and must be discarded before they are worn out. This loss is in the nature of depreciation and is usually classed as such." (603)

**§323 Depreciation by Supersession.**—This is synonymous with functional depreciation, as defined in §320.

**§324 Obsolescence Due to Exercise of Police Power.**—Many municipalities may cause the obsolescence of much otherwise good equipment thru the exercise of their general police powers in compelling Utilities to change equipment, as for instance, in the elimination of grade crossings or removal of overhead wires.

**§325 Amortization of Obsolete Investment.**—In general, in accordance with the doctrine quoted in §314 and §315, it is presumed there is available a depreciation fund large enough to replace capital shrinkage due to functional depreciation. " Equipment which has been cast aside for larger units, more adapted to the present use of the plant, or which has been abandoned as impracticable, cannot be included as a part of the valuation, serving as a basis for adjustment of rates." (723)

Yet an exception may be made as follows: When the functional depreciation has taken place so rapidly that the earnings have not permitted the amortization of the obsolete capital, then the obsolete capital ought not be deducted from the normal capitalization, in determining a fair capital basis for adjustment of rates.

**§326 Relation of Normal Maintenance and Depreciation.**—Maintenance and depreciation are closely related. Yet no mere system of maintenance will provide for the inevitable wasting of assets which may go on simultaneously from all the sources given in Fig. 20, p. 103.

"Renewals depend upon depreciation but, unlike depreciation, are not constantly going on. Renewals or replacements are made only when the various parts have outlived their usefulness and must be replaced. There may be long periods in the life of a plant during which depreciation is accumulating, but when no renewals of any con-

FIG. 21

DEPRECIATION OF WOOD BY TEREDO.

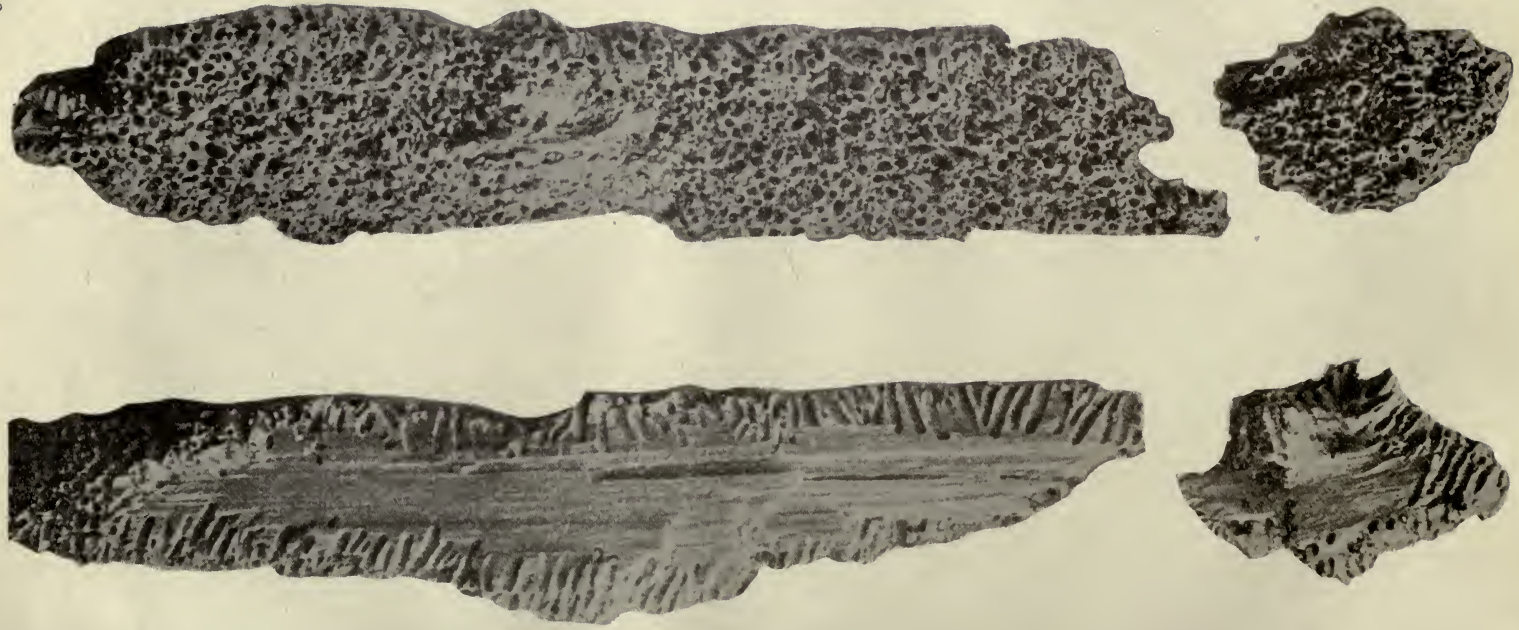


FIG. 22

DEPRECIATION OF WOOD BY LIMNORIA.

THE UPPER VIEW SHOWS THE SURFACE APPEARANCE AND THE LOWER VIEW SHOWS THE DEPTH OF HOLES.

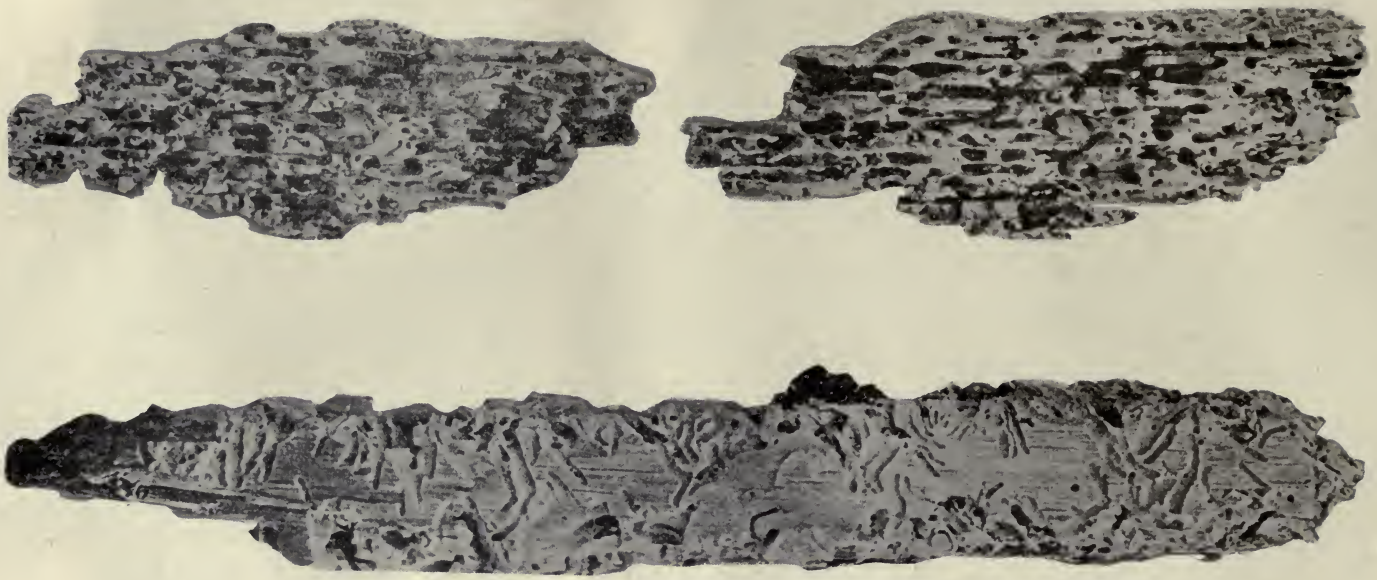


FIG. 23

DEPRECIATION OF WOOD BY CHELURA.

THE UPPER VIEW SHOWS THE SURFACE APPEARANCE AND THE LOWER VIEW SHOWS THE DEPTH OF HOLES.

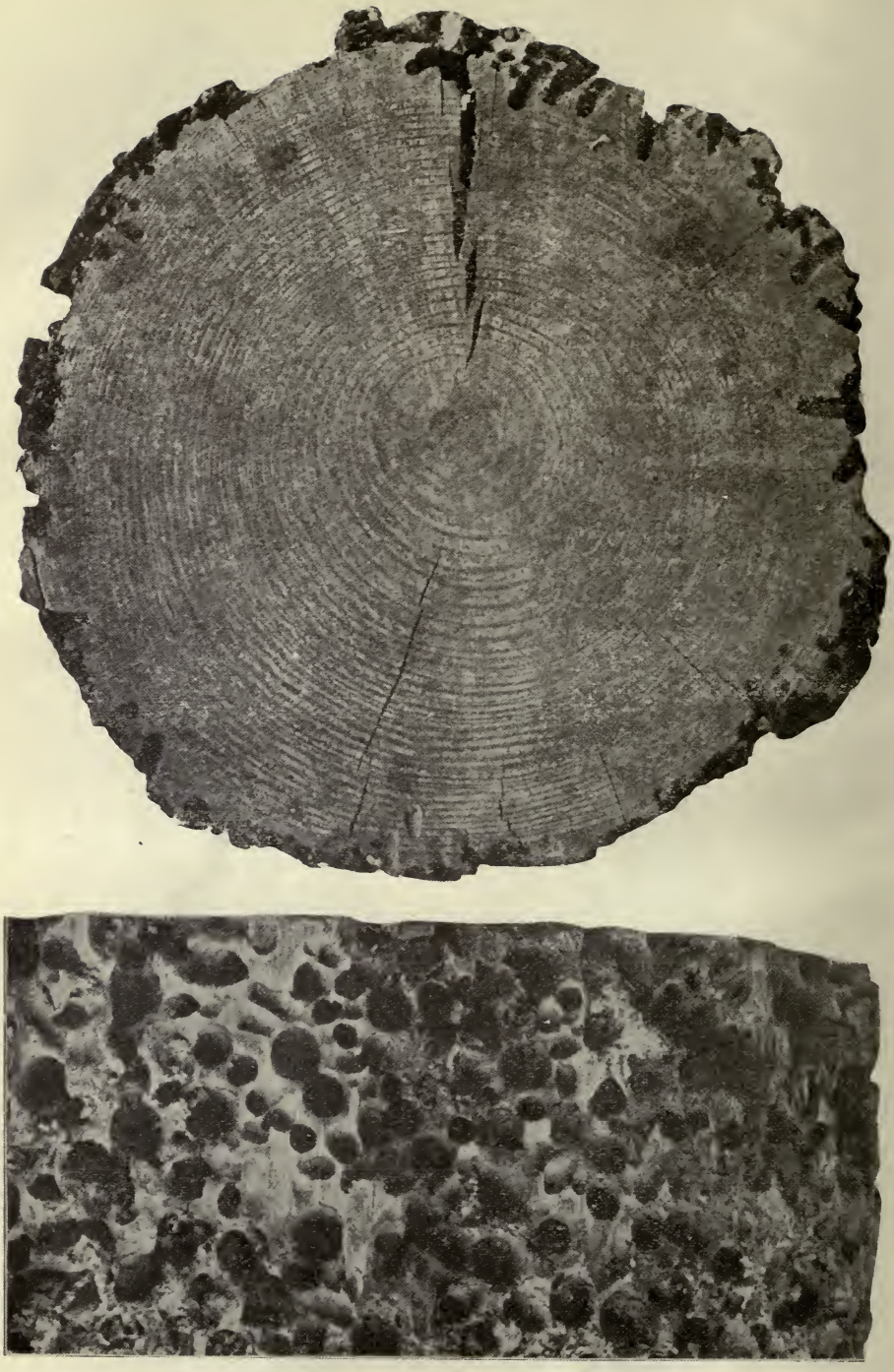


FIG. 24

DEPRECIATION OF WOOD BY SPHAEROMA.

THE UPPER VIEW IS A CROSS SECTION OF LONG LEAFED YELLOW PINE, PILE; THE LOWER VIEW SHOWS THE SURFACE APPEARANCE.

FIG. 25

DEPRECIATION OF WOOD BY POLE BORER.

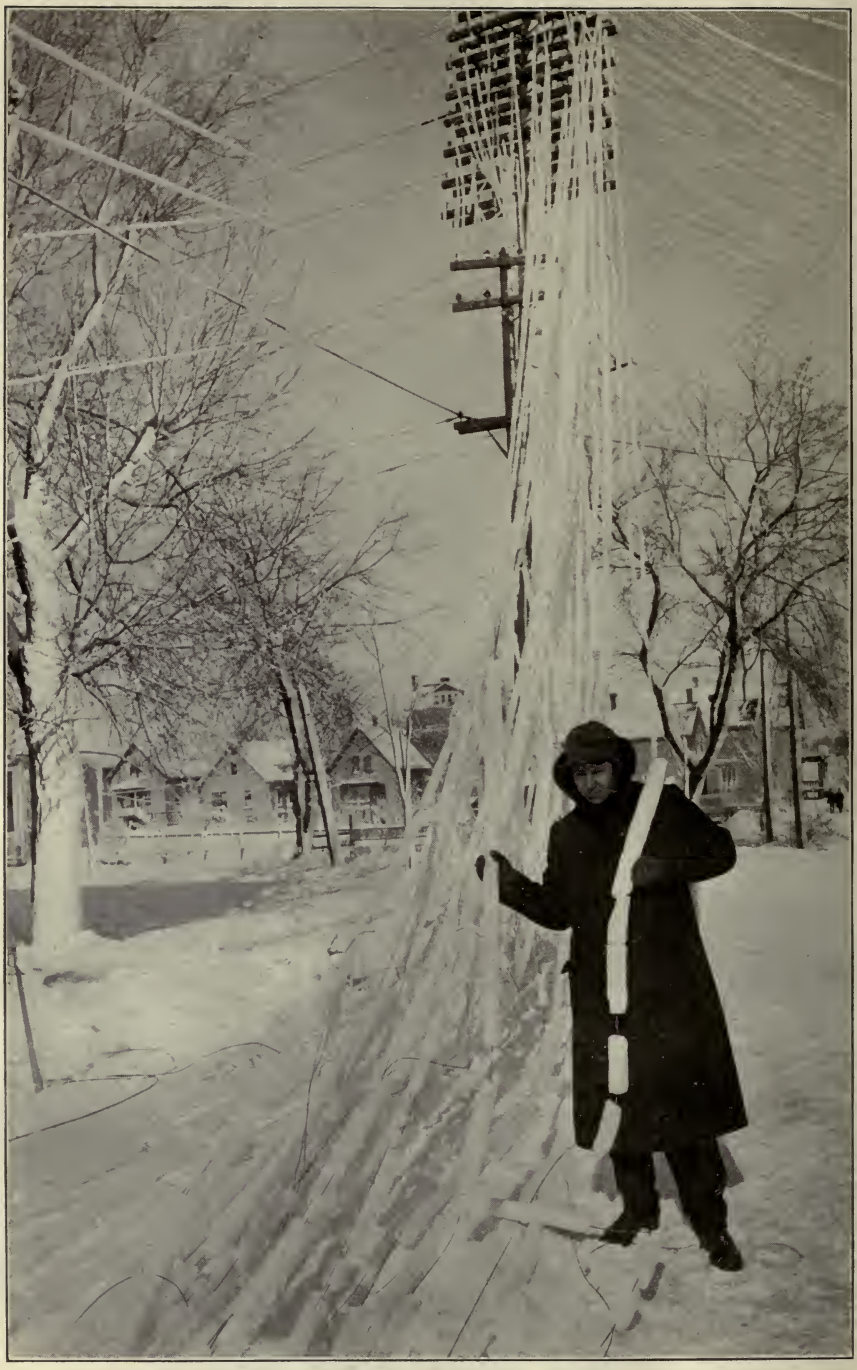


FIG. 26

DEPRECIATION CAUSED BY SLEET STORM.

FIG. 27

DEPRECIATION OF LEAD TELEPHONE CABLE BY SQUIRRELS.

FIG. 28

TUBERCULATION OR GROWTHS IN WATER MAIN.

siderable proportions are made. It is seldom safe to assume that, during any given period, the depreciation and the renewals amount to about the same thing." (711)

"The allowance for depreciation will depend, to some extent, upon the practice of the company regarding its maintenance accounts. The distinction as to what are repair items and what is depreciation is not always clearly drawn, and practice has differed as to just where the cost of certain renewals should be charged. In a measure, the expenditures for repairs and depreciation must complement one another and together be sufficient to maintain the property as closely as possible to its initial efficiency and value." (712)

**§327 Deferred Maintenance and Depreciation.**—"Deferred maintenance is only another term for neglect and always reflects to the discredit of the management or the financial ability of a corporation." (97) If property is allowed to run down, it is obvious that the depreciation must be higher.

**§328 Depreciation from Accidents.**—"There is always a certain amount of loss by accident which seems to be inseparable from the business. Usually it can be counted on in advance, and no amount of care or precaution will entirely eliminate it." (529)

**§329 Depreciation Due to Negligence.**—The amount of Utility property destroyed annually by accidents is enormous, and necessitates a large annual outlay from earnings to keep the original investments intact. The relative rank of the different causes of 899 railroad accidents is as follows: (59)

| | |
|---|---|
| Malicious acts caused | 30 accidents |
| Elements caused | 104 accidents |
| Structural defects caused | 117 accidents |
| Various forms of negligence caused | 648 accidents |

**§330 Damages from Utility Negligence.**—"While a citizen may have no individual claim against a company contracting to supply water to a city, for its failure to do anything under the contract, he may have a claim against it, after it has entered upon a contract and is engaged in supplying the city with water, for damages resulting from negligence and in such a case the action is not for breach of contract but for a tort." (470)

**§331 Depreciation Due to Elements.**—Insurance against damage from fire, lightning, water or wind will never cover all the losses arising from these sources. The destruction even of insured physical property will always injure the Utility indirectly, but nevertheless vitally. Further, no reputable insurance company will knowingly

insure for absolutely full cost, for this would cover the sum of the intangible and physical costs. Every winter results in destruction to pipe lines due to freezing of condensation in gas mains and water in water mains. The damage to overhead wires resulting from a sleet storm is shown in Fig. 26, p. 110. In Utilities using overhead wires, a close relation exists between line troubles and atmospheric conditions.

**§332 Depreciation Due to Structural Defects.**—The most thoro engineering inspection of equipment will not always reveal incipient or hidden structural defects. These may remain dormant for several years and then without warning cause a costly accident, resulting in destruction of property and damage suits.

**§333 Parasites** (102, 105, 142).—These losses are much heavier than ordinarily supposed and may cause serious damage that must be considered in Utility valuations.

A railroad trestle, which had been standing but ten months, under constant inspection, failed due to the eating away of some of the timbers by borers, causing a costly wreck.

"Construction timbers in bridges and like structures are sometimes seriously injured by wood-boring larvae, and sometimes reduced in efficiency from 10 to 100 per cent. In a transmission line 40 miles long and 36 chestnuts poles to the mile, after 12 years use, 600 poles had been rotted off at the top of the ground, and inspection showed that 95 per cent of the damage was directly or indirectly due to insects. Poles that appear sound on the exterior may have the entire basal interior riddled, and the work of the borers is not noticed until the poles break off." (273)

The well-known borers are classified as follows:

| | |
|---|---|
| 1. Teredo. | Work in water only. |
| 2. Limnoria. | |
| 3. Chelura. | |
| 4. Sphaeroma. | |
| 5. Pole Borer. | Works in dry only. |

**§334 Teredo** (105).—The Teredo is a very ancient form of life. The seven species that have been identified are similar in their principal characteristics but vary as to local habits. The body of the

Teredo resembles that of a long worm; it exists upon infusorial life and may live for a short time out of water. More than 50 per cent of the weight of the wood may be removed by the Teredo, without being greatly manifested upon the surface. Some species live in salt water only, others in fresh water. All varieties of wood commonly used in construction are subject to attack. Fig. 21, p. 105, shows how this pest can depreciate the value of a piece of wood.

**§335 Limnoria** (105).—The Limnoria, also known as "wood louse," is about the size of a grain of rice. The little galleries excavated by it are about ½ inch long and only slightly larger than the borer. These galleries extend in radially, side by side in countless numbers, so that the wood partitions between them are very thin. It requires pure salt water and cannot exist in dirty or fresh water and works in about one inch per annum. Fig. 22, p. 106, is a striking illustration of the havoc wrot.

**§336 Chelura** (105).—The Chelura resembles an ordinary shrimp and is about 1/3 inch long; it is sometimes called the wood shrimp. It prefers soft wood and works in the soft annular rings. An illustration of its work is shown in Fig. 23, p. 107.

**§337 Sphaeroma** (105).—The Sphaeroma resembles the Limnoria but is not limited to salt water. Its work is shown in Fig. 24, p. 108.

**§338 Pole Borer.**—"This is a creamy-white, wrinkled, round-headed, wood worm which hatches from an egg deposited by a shiny, mahogany-brown winged beetle from two-fifths to four-fifths of an inch in length. The insect is very widely distributed, and the injury consists in large mines in the wood as shown in Fig. 25, p. 109. The borers usually work in the outer layers of the wood; the greatest damage is to that area just below and just above the surface of the ground. The beetle will attack wood that is perfectly sound, but evidently prefers to work where the wood shows signs of incipient decay; it will not work in wood that is punky or has wet rot. The damage is apparently greatest and the borers are most abundant where poles are set in high or level dry ground, under good conditions of drainage. Where the wood is in wet sites there is usually but little injury by wood-boring insects except to that portion near the surface of the ground. Conditions of drainage are more important than different soil combinations, and the condition of the soil is more important than its composition." (273)

"This insect is an important factor in decreasing the normal length of service of poles. At least 10 per cent of the chestnut poles reset or replaced are injured by insects." (273)

**§339 Woodpeckers.**—In a pole line recently examined, over half of the poles had their cross-sectional area reduced one-half by woodpecker holes.

**§340 Squirrels.**—A telephone cable destroyed at Ann Arbor, Mich., by squirrels gnawing holes in the soft lead sheath, thereby short-circuiting the lines, is shown in Fig. 27, p. 111.

**§341 Deterioration of Water Supply.**—A domestic water supply may deteriorate by becoming stained, soiled, tainted, putrid, polluted, or infected, as discussed in §777 to §782. In extreme cases, the doctrine given in §198 and §204 may result in the Utility being deprived of its domestic revenue.

**§342 Algae Growths in Water Supplies** (77, 274, 275, 280).—The death and decay of minute vegetable growths known as algae may cause a marked depreciation in a water Utility. These algae, too little known to possess a common name, are responsible for most bad odors and tastes in drinking water; they are widely distributed and reservoirs in many States have been rendered unfit for use by their presence. It must be understood, however, that not all tastes and odors found in water are caused by algae. There are other agencies which affect these qualities, among which are oil wastes, salt, sulfur, organic matter and the growths discussed in §344 and §345.

Algae do not develop in pure water or in the dark, but must have nitrogenous food and sunlight for their development. While the odor may become so strong as to render the water unfit for domestic uses, it has never been proved that the algae are productive of disease. The appearance of algae is familiar to all in the form of green scum popularly known as "frog spawn" or "pond scum."

"The fresh water algae are divided into two classes with regard to color, namely: blue-green algae and green algae. Each of these groups includes numerous varieties, the identification of which is sometimes difficult. The blue-green algae produce grassy or moldy odors, while the green algae are characterized by a fishy or oily smell. Some of the growths appearing early in the summer are aromatic or sweetish. These odors become intensified as the algae increase in numbers and as others decay." (222)

**§343 Mineral Growths in Water Mains.**—The alkalinity of some water has a tendency to precipitate other mineral constituents and thus form a scale or coating on the interior of the water main, as shown in Fig. 28, p. 112.

"Tuberculations are formed by the corrosion of imperfectly protected iron, and begin as minute projections dotted over the surface. They grow by addition in concentric layers and increase in size and numbers until they ultimately become confluent and form a coating of considerable thickness. Tuberculation is not the result of iron organisms; the nodules are a modified form of rust, the growth of which may be accelerated by the carbon dioxide liberated by organisms present in the water." (132)

"Tuberculation will not occur when the iron mains are effectively protected by any means from contact with the water. The presence of organisms in the tubercules is mechanical rather than biological, and are not necessary to the growth of the tubercle." (132)

The iron of the tubercules is in all cases derived from the iron of the pipes and is dissolved out where tuberculation occurs. Underneath the tubercle the iron is frequently soft and spongy and has partially wasted away by oxidation. (132)

**§344 Vegetable Growth in Water Mains** (127).—The generic name for this is Crenothrix, and the three known species are Crenothrix Kuhniana, Crenothrix Manganifera, and Crenothrix Ochracea, depending upon whether iron, manganese or alumina is secreted. It belongs to the lowest form of life, is of simple structure, reproduces itself rapidly and undergoes decomposition quickly. Two conditions are necessary for its growth in water mains:

1. Organic matter in water to give necessary tissue.

2. Minerals,—iron, manganese or alumina,—the particular mineral indicating the species that may subsist on it.

**§345 Animal Growths in Water Mains.**—"Bryozoa form moss-like aggregations which frequently attain considerable size. The coating or growth developed by these in pipes occurs in branching interlaced filaments, covering large areas to a considerable thickness." The term "pipe moss" is also applied to this growth. (132)

Some waters have a tendency to develop sponge growths. There are many species of these; they grow rapidly, and attach themselves firmly to the mains.

**§346 Results from Removal of Water Main Growths.**—Water main growths can and ought to be removed. The difference in carrying capacity of water mains before and after cleaning is shown in the summary of tests given in Table 15, p. 250. (137)

**§347 Depreciation Due to Diminution of Water Supply.**—A water Utility may be caused unusual depreciation expenses by a diminution of its supply, and, in extreme cases, may have its contract cancelled; see §201.

"That the supply is at times adequate and wholesome is not enough. The wants of the public must under all conditions be supplied." (503)

"A company which seeks and obtains a franchise to supply a certain territory with water for public and domestic uses is under a moral and legal obligation to furnish a supply which shall be equal to all emergencies which may be reasonably anticipated, including unusual drouths and unusual conflagrations, and to bear constantly in mind the prospective increase in population and a consequent increased demand for water." (584)

**§348 Depreciation Due to Diminution of Natural Gas Supply.**—This is shown in Fig. 29, p. 119, which is the actual record of a typical operating company. In the Sugar Grove field the average life of:

128 abandoned wells was 3 years, 11 months.

68 producing wells was 6 years.

193 abandoned and producing wells was 4 years, 7 months.

**§349 Depreciation of Intangible Property.**—The worth of nearly all intangible Utility property is closely related to the physical property that was benefitted by the original intangible investment, and varies with its worth. Intangible property investment, therefore, should be amortized in a manner similar to its connected physical property.

Intangible assets which are terminable after a definite number of years, such as term franchises, should be amortized in equal amounts proportioned to the number of years of life of the asset.

**§350 Ordinary Depreciation.**—This represents the depreciation due to the gradual decay, wearing out of equipment or termination of rights.

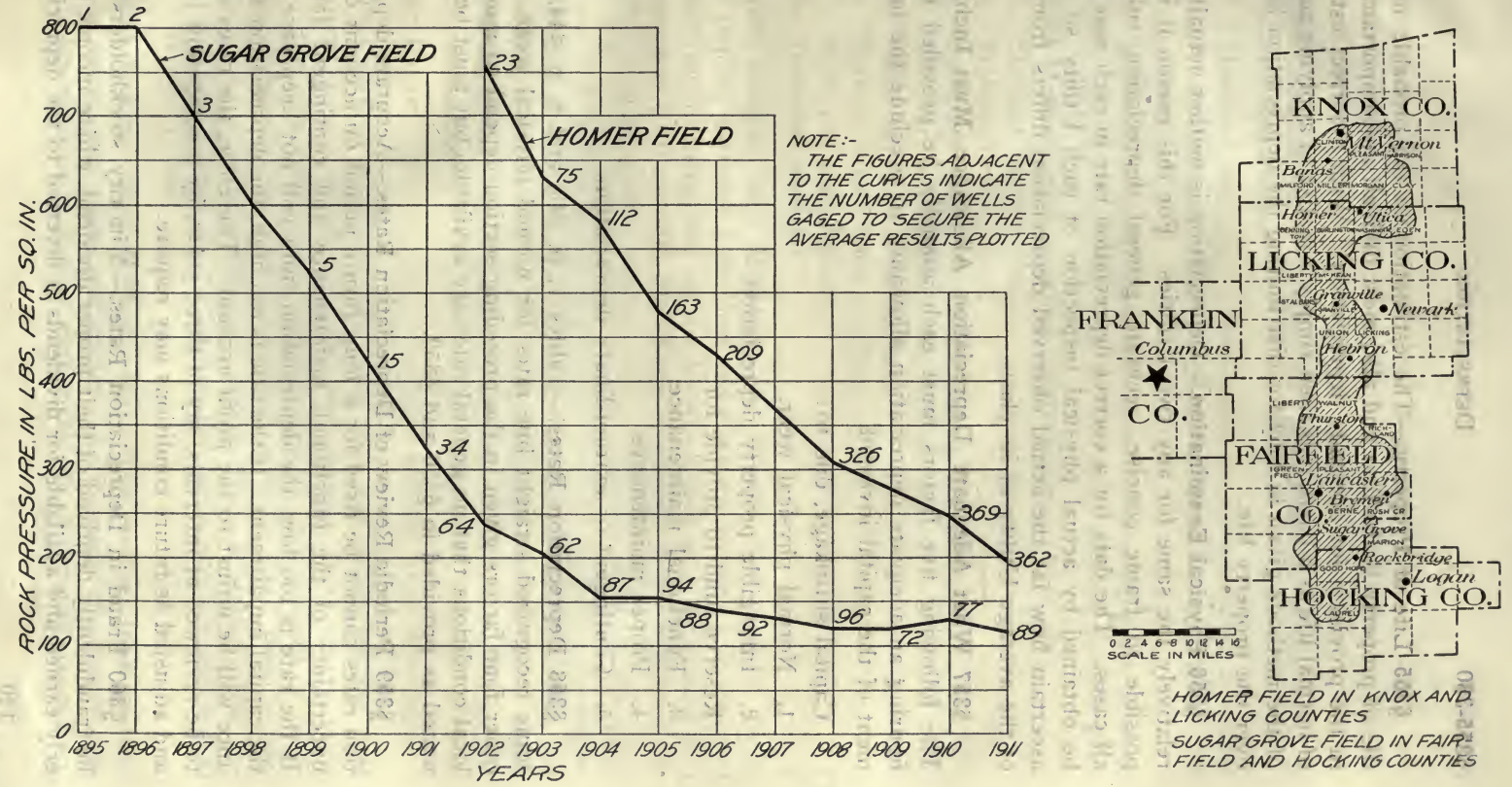
**§351 Extraordinary Depreciation.**—This is the depreciation due to some unforeseen casualty.

**§352 Total Depreciation.**—The total depreciation of a Utility is the combined effect of the five forms of depreciation given in Fig. 20, p. 103.

**§353 Complete Depreciation.**—"Complete depreciation represents that part of the original plan that thru destruction or obsolescence has actually perished as useful property." (482)

**§354 Incomplete Depreciation.**—"Incomplete depreciation represents the impairment in value of the parts of plant which remain in existence and are continued in use." (482)

# FIG. 29
# DEPRECIATION OF NATURAL GAS WELLS IN OHIO




HOMER FIELD IN KNOX AND LICKING COUNTIES

SUGAR GROVE FIELD IN FAIRFIELD AND HOCKING COUNTIES

**§355 Life of Property.**—The estimation of the probable normal life of property is the first and also most difficult and important step in the provision for adequate depreciation. With a correct estimate of normal life as a basis, it is then simply a matter of applying any one of the methods given in §362 for distributing the depreciation burden over the property life.

**§356 Physical Examination.**—Depreciation is neither actually nor relatively the same for any two Utilities. For this reason it is impossible to frame concise, accurate general depreciation rules for all cases. The data for a correct depreciation rate in each case must be obtained by actual physical inspection of each Utility so as to ascertain how far the actual observed depreciation differs from that of the average Utility of its class.

**§357 What Adequate Depreciation Allowance Must Include.**—The following five factors must each annually be provided for in figuring an adequate depreciation allowance to preclude the impairment of the capital invested.

Capital shrinkage, due to:

1. Normal physical wear.
2. Intangible property depreciation.

Reserve fund to provide for:

3. Functional maintenance.
4. Proper maintenance.
5. Contingent or extraordinary depreciation.

**§358 Depreciation Rates.**—Tables 7, p. 243, and 8, p. 244, give some recognized straight line rates for normal physical wear. The other four factors given in the preceding section depend so much on local conditions that no general rates are available, but must be estimated as provided in §356 and §359.

**§359 Periodic Review of Depreciation Rates.**—Accurate depreciation rates cannot be fixed for a long future period on account of the uncertainty of the functional, maintenance and contingent factors. If the rate is too low, the depreciation fund will not keep pace with the capital impairment. If the rate is too high, the depreciation allowance will be unjust to the profit account. Therefore, the rates ought to be reviewed at intervals, say of three years, by a competent judge, and adjusted as future conditions may require.

**§360 Fraud in Depreciation Rates.**—Minority stockholders may be fraudulently deprived of their proper dividend, where income properly earned and available for dividends is diverted to the depreciation

fund by virtue of an abnormally high depreciation rate. In this way the future interests of the majority may be safeguarded at the expense of the minority.

**§361 Methods for Providing for Depreciation.**—These may be divided into two classes:

1. Maintain integrity of investment by accumulating a reserve fund to replace property likely to go out of service as a unit at some particular time.

2. Maintain integrity of investment by replacing parts of property each year in accordance with the insurance method given in §371.

**§362 Methods of Computing Depreciation.**—These are:

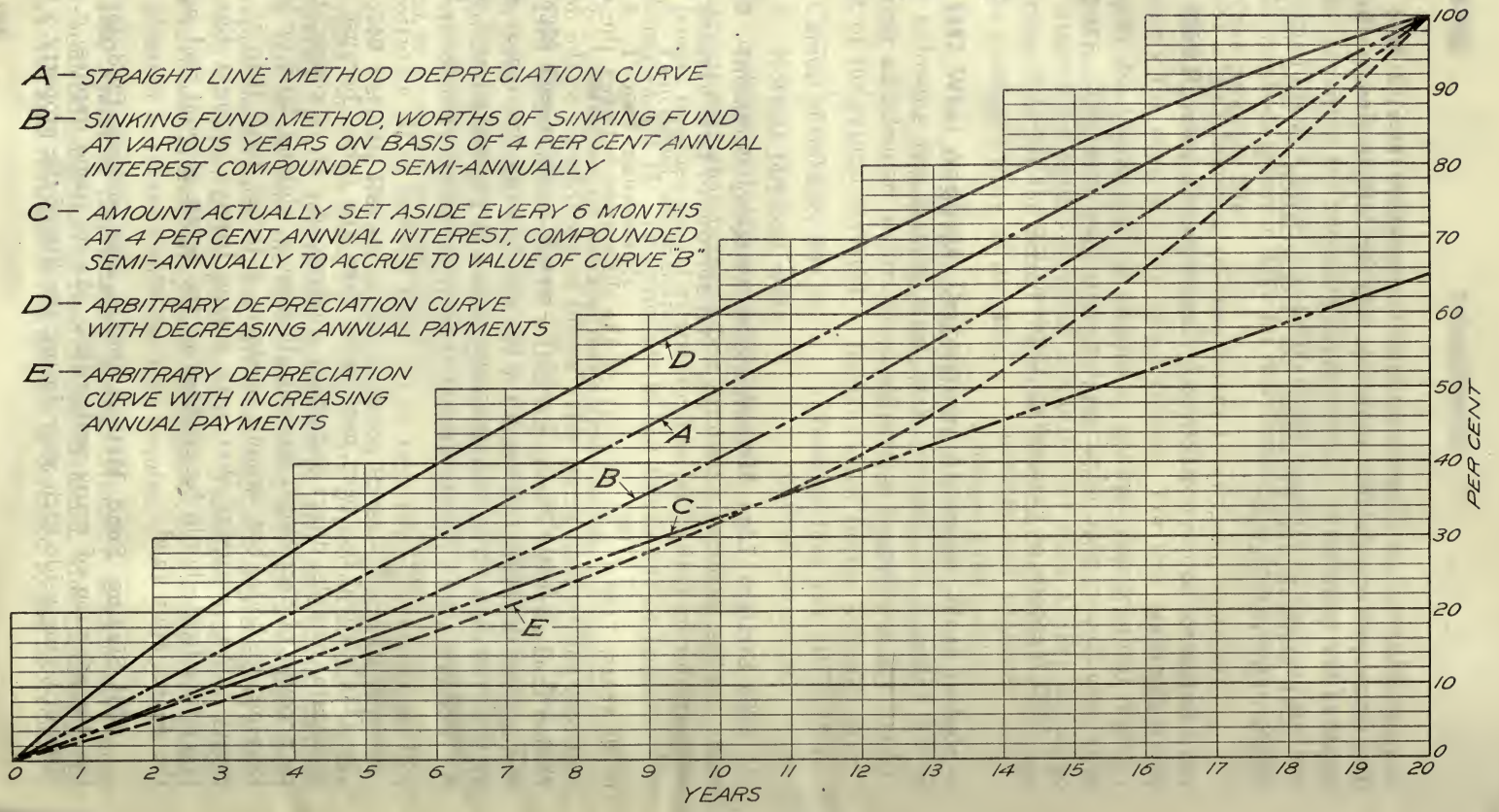
1. Straight line method.
2. Sinking fund method.
3. Arbitrary method with decreasing payments.
4. Arbitrary method with increasing payments.
5. Gross earnings basis method.
6. Service output basis method.
7. Fifty per cent method.
8. Insurance method.

**§363 Straight Line Method.**—The straight line method, as its name implies, assumes a uniform and constant reduction in value of property for its entire life, and consists in laying aside an annual sum proportioned to the useful life of the property. If the assumed life is 20 years, 1/20 ($\frac{100}{20} = 5\%$) of the difference between the original cost and its final scrap value would be contributed to the depreciation fund annually during the entire 20 years of assumed life. For instance, at the end of 15 years the remaining 5 year life value would be ¼ of the total. This is graphically shown in Fig. 30, p. 122, by line A. For in n year's life the annual amount set aside, without interest, will be 1/n or $\frac{100}{n}$ per cent of the total amount to be amortized.

This method has been used more than any other, because it is so natural, simple, direct and easily understood. It, of course, takes no account of accretions, interest allowances, sinking fund or bookkeeping methods, but usually produces a larger fund than is necessary. Any earnings that may accrue from a straight line depreciation fund should be credited to the profit account and not to the depreciation fund.

**§364 Sinking Fund Method** (683).—The sinking fund method has the sanction of many authorities. As its name implies, it consists in laying aside each year during the life of the property a fixed

# FIG. 30
# DEPRECIATION CURVES


A — STRAIGHT LINE METHOD DEPRECIATION CURVE
B — SINKING FUND METHOD, WORTHS OF SINKING FUND AT VARIOUS YEARS ON BASIS OF 4 PER CENT ANNUAL INTEREST COMPOUNDED SEMI-ANNUALLY
C — AMOUNT ACTUALLY SET ASIDE EVERY 6 MONTHS AT 4 PER CENT ANNUAL INTEREST, COMPOUNDED SEMI-ANNUALLY TO ACCRUE TO VALUE OF CURVE "B"
D — ARBITRARY DEPRECIATION CURVE WITH DECREASING ANNUAL PAYMENTS
E — ARBITRARY DEPRECIATION CURVE WITH INCREASING ANNUAL PAYMENTS
D
A
B
C
E
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
YEARS
0 10 20 30 40 50 60 70 80 90 100
PER CENT

sum which, with its accretions of interest compounded regularly at a proper rate of interest, will produce a sum equal to the original property cost less its scrap value or, what is the same thing, the amount to be amortized.

The sinking fund requires constant care so that the interest accretions upon the uniform regular payments will be properly compounded at regular interest so as to secure the compounding effect of the interest earnings. The cumulative effect of compound interest is shown in Table 2, p. 239; Table 3, p. 240, and in Fig. 30, p. 122, lines B and C. Thus, in Table 2, at end of 20 years—column A—the aggregate of the regular payments to the sinking fund amounts to $40—Col. B—but the worth of this $40, at 2 per cent compound interest, is $49.37—Col. C—and at 5 per cent compound interest, is $69.08—Col. F.

In Fig. 30, p. 122, line C represents the actual payments made into the sinking fund, line B represents the accrued worth of these payments at 4 per cent compound interest. The area between B and C represents the cumulative work of the compound interest.

"However, experience seems to prove that in actual practice a sinking fund will not accumulate as rapidly as the tables indicate. There are usually withdrawals in early years which decrease the rate at which the amount compounds. There are also occurrences which cannot be forseen but against which some provision should be made." (683) This emphasizes the review precaution given in §359.

**§365 Application of Sinking Fund Method.**—1. What amount must be set aside at beginning of each six months and invested at 4% annual interest compounded semi-annually to redeem $10,000 at end of 20 years?

In 4% column of Table 4 and 20 year horizontal line, we find that $1.623 will be required to redeem $100. Hence to redeem $10,000 there will be required $\frac{10{,}000}{100} = 100$ times this amount or $1.623 $\times$ 100 = $162.30.

2. What amount will actually be paid into the preceding sinking fund at end of 20 years?

Since the payments are made every 6 months, it is evident that 40 payments will be made in 20 years. These will amount to $162.30 $\times$ 40 = $6492.00 or 64.92% of the total $10,000 to be redeemed. This corresponds to the point of intersection of line C with 20 year vertical line on Fig. 30, p. 122.

The cumulative work of the 4% compound interest equals the difference between the $10,000 accrued and the $6492 actually paid in, i. e., $3508.

3. What is the accrued worth of the preceding sinking fund at end of 10 years?

In 4% column of Table 2 and 10 year horizontal line, we find that $1 invested at beginning of every six months has an accrued worth of $24.7833. The sinking fund payment has been calculated in problem 1 to be 162.3, the accrued future worth of this sinking fund at end of 10 years will be 162.3 times the accrued worth of the $1.00 or $24.7833 × 162.3 = $4022. or 40.22% of the total $10,000 to be redeemed. This corresponds graphically to the intersection of line B and the 10 year vertical line in Fig. 30, p. 122.

4. What amount must be set aside at end of every year, and invested at 4% annual interest, compounded annually, to redeem $10,000 at end of 20 years?

In 4% column of Table 5, p. 242, and 20 year horizontal line, we find that $3.36 will be required to redeem $100. Hence to redeem $10,000 there will be required $\frac{10{,}000}{100} = 100$ times this amount or $3.36 × 100 = $336.

5. What amount will actually be paid into the sinking fund and invested at 4% annual interest, compounded annually, to redeem the $10,000 at end of 20 years?

Problem 4 shows that the annual amount is $336. Hence total for 20 payments is $336 × 20 = $6720 or 67.2% of the total $10,000 to be redeemed.

**§366 Arbitrary Method With Decreasing Payments.**—In this method, instead of laying aside a uniform amount each year, as is done in the straight line and sinking fund methods, merely an arbitrary amount is set aside each year with large payments at the beginning and then decreasing toward the end of the property life, as is illustrated by line D in Fig. 30, p. 122.

The arbitrary amounts may or may not be placed at compound interest. However, if they are placed at compound interest, the actual arbitrary amount set aside each year would fall below the line D of Fig. 30, p. 122, by an amount equal to the cumulative effect of the specific compound interest rate received, in a manner somewhat similar to that shown between B and C of Fig. 30, p. 122. The total future worth of the aggregate arbitrary amounts at the end of the property life must be equal to the investment that is to be redeemed.

**§367 Arbitrary Method With Increasing Payments.**—The operation of this is similar to that described in §366, but the early arbitrary payments are made small and then arbitrarily increased toward the end of the property life, as is illustrated by line E in Fig. 30, p. 122.

**§368 Gross Earning Basis Method.**—This used "a fixed percentage of the gross earnings and is a convenient and widely used method. It has the advantage of regulating the amount provided for depreciation in accordance with the gross income, but a fund so provided may have no proper relation to the deterioration actually taking place in the property because it is fixed entirely independently of the invested values." (97)

**§369 Service Output Basis Method.**—This consists of three steps: First, determine the total annual amount that must be placed in the sinking fund to redeem the investment at the end of the property life. Second, determine the total service units output; as for instance, K. W., car miles, M. cu. ft. gas or M. cu. ft. water. Third, divide the first by the second and this will give the depreciation burden per unit of service output.

**§370 Fifty Per Cent Method.**—This is based on an easily determined average, but restricted to rigid limitations. To make it applicable, the following 8 restrictive conditions must prevail.

All the elements entering into each constituent class:

1. Must be similar.
2. Must have the same characteristics.
3. When defective, must be removed piecemeal.
4. Must be under the same service conditions.
5. Must have been renewed once.

The property:

6. Must include a large number of parts.
7. Repair account must have reached its normal maximum.
8. Must have been in use long enough so that the constituent parts represent all possible stages of condition, i. e., from full or 100% wearing value to 0% wearing value.

When the 8 preceding conditions prevail, the wearing value ranges from 0% to 100% with a mean value obviously of $\frac{0\% + 100\%}{2} = 50\%$ of cost. Hence, under such restricted conditions, 50% of cost, less salvage, may immediately be written off as depreciation.

**§371 Insurance Method.**—This is applicable only to Utilities, as the railroads for instance, having property made up of a large number of separate and widely distributed units. It receives its name from the fact that it "involves the actuarial principles of ordinary insurance. This means that the fund accumulated by depreciation charges should not be reserved as an accumulation until it can be

spent for the purpose of replacing the identical property upon which the fund accumulated when such property is abandoned but, on the contrary, that this fund should be expended, in whole or in part, during the year in which it is created, in the replacement of equipment." (277)

**§372 Composite Nature of Utility Plants.**—A glance at Tables 7, p. 243, and 8, p. 244, makes evident the large variation in the depreciation rate of the different elements composing a Utility plant. This means that, in order to maintain properly the entity of the plant, the short life elements must be replaced several times during the normal life of the plant as a whole, as indicated in columns A and C of Fig. 31, p. 127.

**§373 Scope of Depreciation Reserve** (698).—An estimate of the proper amount yearly to be contributed to the depreciation must consider the following:

1. Life of each separate unit of equipment.
2. Value of each separate unit of equipment.
3. Scrap value of each separate unit of equipment.
4. Interest that reserve may earn.

**§374 True Average or Composite Life.**—"This is the number of years elapsed when the plant will have depreciated an amount equal to the first cost, and hence, necessarily, the number of years when the accumulated payments to cover depreciation will have amounted to the first cost of the plant." (11)

**§375 Composite Life Determination** (11).—A typical composite life problem is shown in Fig. 31, p. 127. The three methods for solving this are:

1. True basis, by straight line method.
2. Practically true basis, by sinking fund method.
3. False basis, by average life method.

**§376 True Average or Composite Life by Straight Line Method** (11).—In this the actual amount of estimated depreciation is set aside each year. No interest accretions are considered, and the true average life is the time required for the annual straight line depreciation payments to become equal to the first cost of the plant.

Column J of Fig. 31, p. 127, gives the annual amounts required to redeem the respective life elements. The true dollar years, i. e., the product of the total number of years and dollars involved in each life group, must obviously take into consideration that the respective life groups must be replaced the number of times indicated in column C. Hence, the true dollar years equals products of columns A and D.

# FIG. 31
## TYPICAL COMPOSITE OR AVERAGE LIFE DEPRECIATION PROBLEM

| PARTS OF PLANT | | RENEWALS IN 40 YEARS | | AMOUNT TO BE SET ASIDE EACH YEAR TO MAINTAIN INTEGRITY OF INVESTMENT | | | | | | DOLLAR YEARS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SINKING FUND METHOD | | | | STRAIGHT LINE METHOD | | TRUE | FALSE |
| | | | | 3 PER CENT ANNUAL INTEREST | | 6 PER CENT ANNUAL INTEREST | | | | | |
| A<br>LIFE IN YEARS | B<br>VALUE IN DOLLARS | C<br>TIMES $\frac{40}{A}$ | D<br>TOTAL COST BXC | E<br>PER CENT OF B | F<br>AMOUNT IN DOLLARS EXB | G<br>PER CENT OF B | H<br>AMOUNT IN DOLLARS GXB | I<br>PER CENT OF B $\frac{100}{A}$ | J<br>AMOUNT IXB | K<br>AXBXC | L<br>AXB |
| 5 | 10 000 | 8 | 80 000 | 18.84 | 1884 | 17.74 | 1774 | 20 | 2000 | 400000 | 50000 |
| 10 | 20 000 | 4 | 80 000 | 8.72 | 1774 | 7.59 | 1518 | 10 | 2000 | 800000 | 100000 |
| 20 | 30 000 | 2 | 60000 | 3.72 | 1116 | 2.72 | 816 | 5 | 1500 | 1200000 | 600000 |
| 40 | 40 000 | 1 | 40000 | 1.33 | 532 | .65 | 260 | 2.5 | 1000 | 1600000 | 1600000 |
| TOTALS | 100 000 | | 260000 | | 5276 | | 4368 | | 6500 | 4000000 | 2350000 |

$$\text{True average life} = \frac{\text{Total Col. K}}{\text{Total Col. D}} = \frac{4{,}000{,}000}{260{,}000} = 15.4 \text{ years.}$$

**§377 Average or Composite Life by Sinking Fund Method.** (11).—This is the number of years required for a certain annuity with compound interest accretions to accrue to an amount equal to the first cost of the plant, of course taking into consideration the periodic withdrawals necessary to replace the short life elements of the plant.

In Fig. 31 the percentages in columns E and G, opposite the various life periods in column A, correspond to the values for similar years in the 3% and 6% column of Table 5, p. 242. The totals of columns F or H are the annuities that must be laid aside each year at the respective interest rates. The total of column B is evidently the first cost of plant. Hence the question is, how long will it take the annuity to equal B? Obviously the required time will correspond to the per cent that the annuity is of plant value.

$$\text{Annuity \% of plant value} = \frac{\text{Annuity}}{\text{Plant value}} \times 100.$$

$$\text{At 3\% this} = \frac{5276}{100{,}000} \times 100 = 5.27\%.$$

$$\text{At 6\% this} = \frac{4368}{100{,}000} \times 100 = 4.36\%.$$

From the 3% column of Table 5, p. 242, 5.27% corresponds to 15.3 years.

From the 6% column of Table 5, p. 242, 4.36% corresponds to 14.9 years.

**§378 False Average Life Basis.**—This is absolutely misleading and is discussed only as an illustration of how true average life can not be obtained. The method consists merely in averaging the separate life and separate part values. The fallacy consists in ignoring the cumulative renewal cost features of the short life members. Thus, in Fig. 31, p. 127, the false dollar years are given in column L and the true dollar years in column K.

$$\text{The false average life} = \frac{\text{Total dollar years}}{\text{Total value}} = \frac{2{,}350{,}000}{100{,}000}$$

= 23.5 years.

**§379 Comparison of Previous Average Life Methods.—**

1. Straight line time, 15.4 years.
2. 3% sinking fund time, 15.3 years.
3. 6% sinking fund time, 14.9 years.
4. False time, 23.5 years.

Misdirected energy is always an economic waste.

# Chapter 9

## ELECTROLYSIS AS A FORM OF DEPRECIATION

§380 What Is Electrolysis?—Electrolysis is a chemical decomposition produced by an electric current. As applied to Utilities, electrolysis is the disintegration of metal structures caused by the electrolytic action produced by stray electric currents, generally from the return circuits of single trolley electric railways.

§381 What Is a Stray Current?—"Stray currents are electric currents which have leaked from grounded electrical distribution systems and flow thru the ground and underground structures." (140)

§382 Negligible Stray Current Sources.—"Grounded telephone and telegraph lines produce electric currents of such very small magnitudes that their effects upon underground piping systems can be neglected." (140)

"Direct current electric lighting systems, in which the distribution is on the Edison three-wire plan with the neutral conductor grounded, are in American practice provided with such large neutral conductors of copper that practically no stray currents are produced from such systems. This grounding of the neutral in Edison three-wire systems is to serve as a safeguard, and is not for the purpose of using the ground to carry current." (140)

"Alternating current lighting systems, where grounded, generally also produce only small stray currents, and the electrolytic effects from these small stray currents are always negligible." (140)

§383 Importance and Difficulties of Electrolysis.—"The protection of underground structures from damage by electric currents has long been one of the most important, and at the same time one of the most difficult, problems with which the engineer has to contend. There are few problems that affect a greater diversity of interests or which involve the welfare of greater amounts of property than those arising from the presence of stray currents in the earth." (84)

**§384 Electric Conductors.**—There are two classes, namely, metallic and electrolytic.

**§385 Metallic Conductors.**—Metallic conductors carrying currents at normal temperatures undergo no physical or chemical change or wear from such service. Rails, water or gas mains are not injured in the least when acting as metallic conductors; the electrolysis troubles occur only and always where the current leaves them and goes into an electrolytic conductor.

**§386 Electrolytic Conductors.**—With an electrolytic conductor, a physical and chemical change is a condition precedent to actual conduction. Furthermore, the electrolyte must always be placed between two metallic conductors, and the positive one of these, that is, the one sending current **into** the electrolyte, will always be **wasted away** by the electrolytic action.

Street soils generally contain salts dissolved in water and this makes them electrolytes. Hence, the street soil between the rails and adjacent iron mains is generally an electrolyte with the rail as one, and the main as the other, metallic conductor.

**§387 Pure Water Is a Non-Conductor.**—"Pure water itself has such a high resistance that it may practically be considered a non-conductor. It is for this reason that an iron pipe full of ordinary city supply water does not have a lower resistance than the same pipe without water." (140)

**§388 What Is an Electrolyte?**—"By adding salts or acids to water, the resulting solution is known as an electrolyte and is made an electrolytic conductor. Hence conduction through water is always electrolytic." (140)

**§389 Electrolytic Action.**—If two metallic conductors, called electrodes, one of which carries positive electricity, are in contact with an electrolyte, a current will pass from the positive electrode, called the anode, thru the electrolyte to the negative electrode, called the cathode. This electrolytic conduction of current can be made only by the actual breaking away of the ions—i. e., small particles—from the anode. The ions act as carriers of current and, since they come from the anode, it will be gradually corroded or eaten away.

**§390 Specific Cause of Electrolysis.**—Electrolysis is not caused by the current flow, but by the chemical corrosion produced by the acids or salts in the electrolyte which are liberated where the current leaves the metallic conductor to go into the electrolyte.

"In no case is the action due to the electrolysis of water; where oxygen is liberated it does not attack the iron." (141)

**§391 Conditions Necessary for Electrolysis** (81).—These are as follows:

A. Defective return metallic circuit for current.

B. Soil containing salts or acids.

C. Moisture in soil. B and C must be contiguous to A.

D. Metallic conductor like water or gas main adjacent to A, and contiguous to B and C.

The mere fact that a pipe is positive to some other conductor is not in itself evidence that electrolysis is taking place. There must be in addition an electrolytic conductor, in the nature of an acid or alkaline wet soil, between the pipe and the negative conductor, so that the potential difference can cause a current flow from the pipe and produce electrolytic action at the point where the current goes into the electrolyte.

**§392 Continuity of Electrical Circuit.**—It is a universal law that there can be no electric current flow unless there is a continuous, or closed, circuit of metallic or electrolytic conductors.

**§393 Equilibrium Law.**—There is a universal tendency on the part of all unstable conditions in nature to reach a state of equilibrium. The law stated in the next section is based on this phenomenon.

**§394 Law of Divided Circuits** (146).—This is also known as Kirchoff's law, and it applies to metallic or electrolytic conductors.

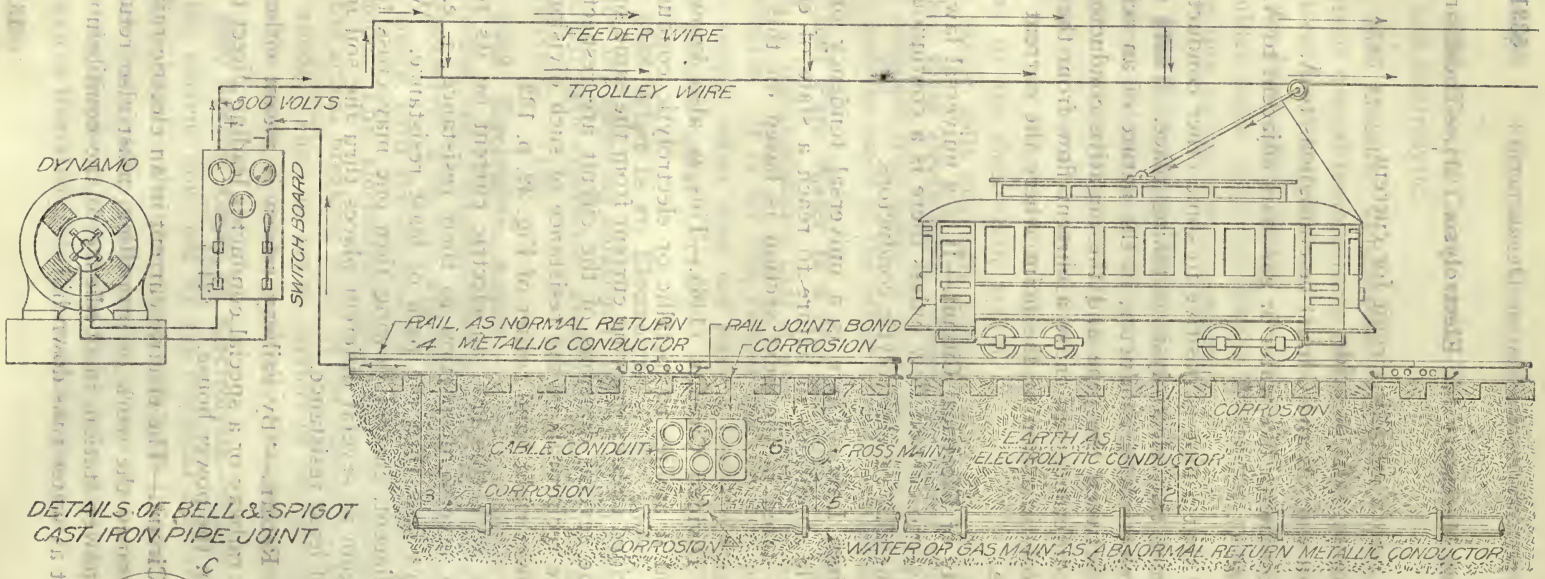
In a set of divided circuits drawing current from the same source, the currents in the several divisions of the circuit are respectively proportional to the reciprocals of the resistance of such divisions, as indicated in the lower right hand corner of Fig. 32, p. 132.

In accordance with this law, an electric current on its return takes all paths in inverse proportion to their resistance; i. e., the current will always flow thru the path of least resistance. Where two mains are adjacent, current flowing thru one may cross to the other and back again at several different places thru the soil in following the path of least resistance.

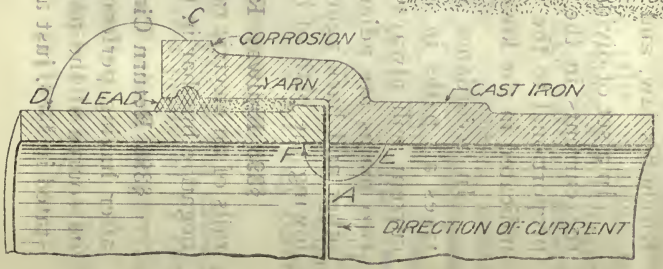
**§395 Railway Return.**—"By railway return is meant either the rails of an electric railway or a special conductor leading direct to the negative bus-bar in the power house." (217)

**§396 Return Circuit.**—The electric current in an electric railroad, after having performed the work of propelling, must also return to its source at the power station, in obedience to the equilibrium law stated in §393, just as water runs down hill.

# FIG. 32
# ACTION OF ELECTROLYSIS




## DETAILS OF BELL & SPIGOT CAST IRON PIPE JOINT



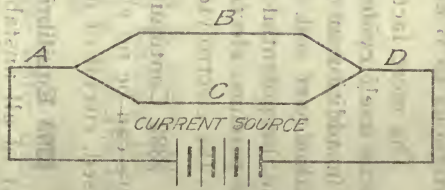




DIAGRAM ILLUSTRATING LAW OF DIVIDED CURRENTS

$$\frac{\text{CURRENT IN ABD}}{\text{CURRENT IN ACD}} = \frac{\text{RESISTANCE ACD}}{\text{RESISTANCE ABD}}$$

The return is made in accordance with the law of divided circuits, as stated in §394.

In Fig. 32, p. 132, if the resistance, due to defective rail bonding, between points 1 and 4, is greater than the path 1, 2, 3, 4, some of the return current will go the latter way, producing corrosion at 1 and 3. If there is a cross main or cable conduit of another distributing system, a part of the current may go from 5 to 6 and 7 to 6, producing corrosion at 5 and 7. Some of the current will usually follow the mains until near the power plant and then return, as from 3 to 4, producing corrosion at 3.

**§397 Relation of Current on Underground Structures to Trolley Load.**—The amount of current in the mains will usually vary with the amount of current delivered by the trolley and be practically proportioned to it. That is, the maximum electrolytic disturbances usually occur during the heavy or peak load on the trolley.

**§398 Action of Street Soils.**—"Street soils when entirely dry do not conduct electric currents. Under ordinary conditions, however, street soils contain considerable water with salts in solution, generally chlorides, and this makes them electrolytic conductors. When an electric current passes thru soil it therefore does so by electrolytic conduction and corresponding chemical decomposition at the electrodes." (140)

"It has been claimed in the past that soils may conduct metallically, but this has been disproved and it is now recognized that conduction of electric current thru soil is always electrolytic." (140)

**§399 Relation of Soil Constituents.**—"Clay, loam and sand stand about in the order of their electrolysis tendencies." (265)

"The nitrates and chlorides are the salts most commonly found in soils. A chloride is very nearly twice as active—considered as a medium of electrolytic action—as a nitrate." (265)

**§400 High Resistance of Soil Will Not Prevent Stray Currents.**—"The conductivity of iron is 250,000,000 times as good as ordinary soil. It would seem from this that current would flow almost entirely on the good conducting rails and none thru the high resistance ground." (140)

"Resistance, however, varies directly as the length and inversely as the cross section of a conductor. With the large surface of rails exposed to the ground, the cross section of the path of the current thru ground is enormously great compared with the cross section of the path of the current thru the rails. As a matter of practice it is found that where the rails alone are used for the return circuit, fre-

quently a considerable portion of the total current actually leaks from rails thru ground." (140)

**§401 Effect of Temperature on Electrolytic Action.**—"Electrolytic corrosion is very greatly increased by the increase of temperature." (88)

"A warm solution of an electrolyte usually conducts better than a cold solution of the same concentration. It has been shown by experiment that frozen solutions of electrolytes practically stop the flow of electricity." (191)

**§402 Amount of Electrolytic Corrosion.**—"This depends upon the strength of the current and the time during which it acts." (81)

**§403 Rate of Electrolytic Corrosion.**—"Iron is eaten away at the rate of 20 pounds per ampere per year and lead at the rate of 74 pounds per ampere per year." (140)

**§404 Relative Corrosive Tendencies of Cast Iron, Wrot Iron and Steel.**—"For a given current leaving an iron pipe, there is practically no difference in the amount of iron destroyed between cast iron, wrot iron and steel." (140)

**§405 Current Carrying Tendencies of Cast Iron, Wrot Iron and Steel Mains.**—"The electrical resistance of cast iron is about ten times as great as that of wrot iron or steel, and the usual lead joints in cast iron pipes also have a resistance which is many times greater than the screw coupling joints usual with wrot iron and steel pipes. For these reasons, a given voltage drop thru ground will cause a much smaller current to flow on a cast iron pipe than on a wrot iron or steel pipe, thus practically making cast iron pipes much less subject to electrolysis than wrot iron or steel pipes." (140)

**§406 Location of Corrosion.**—The corrosion will always occur at the point where the current leaves the metallic conductor (anode electrode) to go into the electrolytic conductor (electrolyte), and can never take place at any other point.

**§407 Pipe Joint Resistance.**—A characteristic of all pipe joints, with the exception of screwed joints, is always to have an uncertain, variable and many times a high resistance. This results in discontinuous and indeterminate electric circuits, producing erratic current flow conditions.

"In ordinary wrot or steel mains with screwed joints, the resistance of the joints is usually small in comparison with that of the pipes, and when such pipes are laid in localities where there is an appreciable potential gradient in the direction of the pipe, currents of considerable magnitude will usually be carried by the pipes." (84)

"In the case of cast iron mains using lead joints, the resistance of the joint is often as great or greater than that of a section of pipe, and it is not uncommon to find a lead joint having a resistance equal to that of several hundred feet of pipe. It is due largely to this fact and the higher electrical resistance of cast iron, that such pipes carry considerably less current under similar conditions than wrot iron or steel pipe." (84)

The high resistance of cast iron pipe joints produces the condition illustrated at the left hand of Fig. 32, p. 132. The resistance, on account of poor contact at A and high resistance of the lead, may cause the current to jump from C to D, producing corrosion at C. If the mains contain impure water—see §338—the current may jump from E to F, producing corrosion at E.

The cement joints used in some cast iron gas pipes have such a high resistance compared with the pipes that they may be practically insulating.

The rubber-seated couplings so generally used on wrot iron and steel high pressure gas lines are exceptionally uncertain in their resistance properties. These joints may vary from almost perfect conductors to practically perfect insulators. Current shunting around these joints almost always corrodes the bolts used for holding the coupling together, thus soon producing a loose and leaking joint.

**§408 Potential Districts.**—Where electrolysis prevails, "in general, in districts distant from the power house, the stray currents flow thru the intervening soil from the rails to the pipes; these are called negative districts. Adjacent to the power house, the current flows from the pipes thru the intervening soil to the rails; this is called a positive district. Between these two districts the stray currents flow from rails to pipes or from pipes to rails, depending upon the distribution of cars; these are called neutral districts." (81)

"The danger region of a piping system is, in fact, by no means confined to the so-called positive districts, but exists at every point where current leaves a pipe to pass into wet soil." (81) For whenever the latter condition exists, electrolysis is sure to take place.

**§409 Current Paths in Earth.**—"As the earth becomes partly saturated with particles of iron, it becomes a better conductor, more current passes and the disintegration increases. Where this action has taken place between lead pipes and the rails, particles of lead have been seen in the earth with the naked eye, and chemical analysis will show the presence of lead and iron some distance from the point where the electrolytic action took place." (262)

**§410 Voltage No Criterion in Electrolysis Problems.**—"It has been assumed by some in the past that no electrolysis can take place if the voltage between two metallic conductors in soil, such as between pipe and rails, is less than 1.5 volts, because this is the dissociation voltage of water. This, however, is entirely wrong, and it has been proven by investigations and is now generally recognized that the amount of corrosion produced by electrolysis is independent of the voltage, except in so far as this determines the amount of current flowing, and that the smallest fraction of a volt can produce corrosion from electrolysis under suitable conditions." (140)

"A mere directing force, in the nature of a pressure, may cause electrolysis." (141)

It must also be remembered that "voltmeter readings are not sufficient to determine the existence and extent of electrolytic corrosion. Direction and strength of current flow in various parts of the system are required in addition to the voltage readings."

"A high potential difference may even under certain conditions indicate a high resistance and a correspondingly small current with little corrosion. A low potential difference may indicate a low resistance, and a large current with a correspondingly large amount of corrosion." (81)

See judicial recognition of this point in §463.

**§411 Electric Current Must Be Known in Electrolysis Problems** (140).—The amount of current flowing on an underground structure must be known, because all current which flows on a structure must leave it, and the amount of damage produced is proportional to the total current which leaves the structure thru an electrolyte. The method for determining the amount of current is given in the next section.

**§412 Electric Current Determination** (140).—This may be done by observing the potential drop in millivolts between two known points and then applying the formula and constants given in Fig. 33, p. 137.

**§413 Nature of Corrosion of Wrot Iron and Steel.**—"Where current leaves a wrot iron or steel pipe for ground, the oxide of iron resulting from electrolysis is diffused thru the soil, and streaks of iron oxide can generally be found in the surrounding soil. Electrolysis of wrot iron or steel pipes usually results in pits which eventually go entirely thru the wall of the pipe." (140)

"It has frequently been found in practice in the case of gas pipes that, where a service pipe lies in clay or other tightly packed soil, it

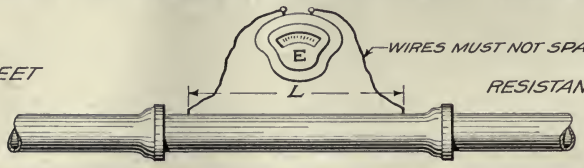
# FIG. 33

# VALUE OF CURRENT FLOW K IN AMPERES FOR 1 MILLIVOLT DROP PER FOOT OF CONTINUOUS PIPE

## BASED ON COMPUTATIONS OF PROF. ALBERT F. GANZ, M.E.

L = DISTANCE BETWEEN CONTACTS IN FEET
E = INSTRUMENT READING IN MILLIVOLTS
K = CONSTANT FROM TABLE

CURRENT FLOW IN AMPERES = $\frac{KE}{L}$




RESISTANCE OF 1 LB. FOOT { CAST IRON = .00144 OHM; WROUGHT " = .000181 "; STEEL = .00021 "

| DIAM. IN INCHES | STANDARD CAST IRON PIPE — AMERICAN WATER WORKS ASSOCIATION, CLASSES — 100 FT. HEAD | 150 FT. HEAD | 200 FT. HEAD | 250 FT. HEAD | 300 FT. HEAD | 350 FT. HEAD | AMERICAN GAS INSTITUTE STANDARD GAS PIPE |
|---|---|---|---|---|---|---|---|
| 4 | | | | | 12.3 | 12.7 | 12.0 |
| 6 | | | 19.3 | 20.2 | 21.2 | 22.1 | 18.9 |
| 8 | 25.9 | 27.6 | 29.5 | 30.8 | 32.7 | 33.9 | 26.4 |
| 10 | 35.7 | 38.0 | 40.0 | 43.3 | 45.7 | 48.6 | 35.5 |
| 12 | 45.2 | 48.8 | 52.4 | 55.8 | 59.5 | 63.3 | 46.8 |
| 14 | 56.5 | 60.7 | 65.8 | 70.0 | 75.2 | 79.3 | |
| 16 | 67.6 | 73.6 | 79.4 | 85.5 | 91.8 | 97.1 | 71.5 |
| 18 | 80.0 | 87.7 | 96.2 | 102. | 110. | 116. | |
| 20 | 92.6 | 101. | 111. | 121. | 132. | 139. | 97.2 |
| 24 | 120. | 135. | 149. | 161. | 175. | 185. | 130. |
| 30 | 170. | 192. | 213. | 233. | 257. | 278. | 179. |
| 36 | 200. | 256. | 286. | 313. | 345. | 385. | 240. |
| 42 | 294. | 333. | 371. | 417. | 455. | 500. | 315. |
| 48 | 371. | 417. | 455. | 527. | 589. | 625. | 429. |
| 54 | 455. | 526. | 588. | 667. | 667. | 769. | |
| 60 | 556. | 666. | 715. | 769. | 909. | 936. | |

| DIAM. IN INCHES | STANDARD WROUGHT IRON PIPE | STANDARD STEEL PIPE |
|---|---|---|
| $\frac{1}{8}$ | 1.33 | 1.15 |
| $\frac{1}{4}$ | 2.32 | 2.00 |
| $\frac{3}{8}$ | 3.09 | 2.66 |
| $\frac{1}{2}$ | 4.63 | 3.99 |
| $\frac{3}{4}$ | 6.17 | 5.32 |
| 1 | 9.27 | 7.99 |
| $1\frac{1}{4}$ | 12.4 | 10.7 |
| $1\frac{1}{2}$ | 14.8 | 12.8 |
| 2 | 19.9 | 17.2 |
| $2\frac{1}{2}$ | 31.8 | 27.4 |
| 3 | 41.7 | 35.9 |
| 4 | 58.8 | 50.7 |
| 6 | 103. | 88.8 |
| 8 | 156. | 134.0 |
| 10 | 222. | 191.0 |
| 12 | 271. | 234.0 |

FIG. 34

PITTING OF CAST IRON PIPE BY ELECTROLYSIS

FIG. 35

DESTRUCTION OF CAST IRON PIPE BY ELECTROLYSIS

FIG. 36

DESTRUCTION OF SERVICE PIPES BY ELECTROLYSIS

THE UPPER ONE IS STEEL AND THE LOWER ONE IS LEAD

may be pitted thru in many places without giving any external sign of leakage, because the soil surrounding the pipe maintains it gas-tight." (140)

A typical case is illustrated at the top of Fig. 36, p. 140.

**§414 Nature of Corrosion of Cast Iron.**—"When cast iron is corroded by electrolysis, the oxide of iron mixed with graphite usually remains in place, leaving the outside appearance of the pipe unchanged. This material resulting from electrolysis usually has the consistency of hard graphite, and can be cut with an ordinary knife. There have been many cases in which a cast iron main was carrying gas or water without any apparent leak, where a single blow with a hammer drove a hole right thru the pipe. Here the electrolytic action had corroded the iron entirely thru the pipe, and the oxide of iron had remained in place and, together with the surrounding soil, had prevented the pipe from leaking." (140)

Typical cases are illustrated in Figs. 34, p. 138, and 35, p. 139.

**§415 Nature of Corrosion of Lead.**—The lead becomes soft, pliable and has a laminated appearance, as shown at the bottom of Fig. 36, p. 140.

**§416 Elimination of Electrolysis** (140).—The methods that have been tried are as follows:

Preventive

1. Double trolley
2. Fourth rail

} Complete insulated return circuit.

Remedial

3. Adequate bonding.
4. Radial return system.
5. Return on other Utility structures.

Protective

6. Insulating joints in mains.
7. Coating.
8. Substitute alternating current for direct current.

Only the preventive methods are entirely safe and efficacious. "To prevent the current from returning by way of the pipes, we must render it impossible for them to become easily available paths." (213)

**§417 Complete Remedy for Electrolysis.**—"There is only one complete remedy for electrolysis, and that is the use of a completely

insulated return circuit. Such railways may be provided with double overhead trolley wires, as used, for example, in Washington, D. C., Cincinnati, O., and Havana, Cuba; or with an insulated outgoing and return conductor in underground conduits, as used, for example, on the surface lines on Manhattan Island; or with separate insulated third and fourth rails for the outgoing and return current, as is used on the Metropolitan District Railway in London. With these systems the running tracks are not used as a part of the electric current and, as both positive and negative sides of the circuit are insulated, no stray currents are produced." (140)

"There is no complete safety from the action of stray currents, unless the trolley roads adopt either the double overhead or the underground systems. They must be driven to it by the hand of the law, or change from a realization of the saving to be made in their coal piles, or better, from a sense of duty to those corporations whose rights, so far as the use of the cities' underground, are as good as theirs. Until then the gas companies' properties will be in jeopardy and life in danger from explosions due to escaping gas ignited by current, which should be confined in adequate return wires." (252)

**§418 What Is Double Overhead Trolley System?**—In this the negative or return current is returned to the power station over overhead wires, and its operation requires:

1. An extra trolley wire adjacent to the one generally used.

2. Extra return copper feeder to drain the extra trolley wire and return the current to the power station.

3. Each car to be equipped with an extra trolley pole, trolley base, trolley harp, and trolley wheel, for the delivery of the return current from the car motors to the overhead negative trolley wire.

**§419 What Double Overhead Trolley System Accomplishes.**—Since none of the return current can come in contact with the wires or ground, the stray currents so universally encountered with the single trolley system are entirely eliminated, and the double overhead trolley system is the only absolutely reliable and permanent means for the prevention of electrolysis of underground structures.

**§420 Data Pertaining to Double Overhead Trolley System in Washington, D. C.**—The data given in this and the following five sections are based on a personal examination of nine miles of The Washington Railway and Electric Company at Washington, D. C., where electrolysis troubles have been eliminated entirely by the use of the double overhead positive and negative trolley system.

NUMBER OF CARS: Under normal traffic conditions 64 cars are operated each day on this double overhead positive and negative trolley system.

MOTORS: Seventy-five per cent of the cars are fitted with two 60-H. P. motors, and twenty-five per cent are fitted with four 32-H. P. motors.

FREQUENCY OF CARS: This varies from forty-five seconds to five minutes. Under normal conditions the cars are distributed about three to a mile, but during the peak load, cars follow each other very closely.

POSITIVE AND NEGATIVE FEEDERS: In this trolley system it is the universal custom to make the negative return feeders of exactly the same size as the positive feeders, and the positive and negative feeder taps to the trolley lines are spaced approximately 1,000 feet apart. The following is a summary of the feeder conditions of the entire system, the larger part being double parallel track construction:

| | Area in Circular Mills. | Weight per Thousand Ft. |
|---|---|---|
| 8,200' | 811,000 | 2,441 lbs. |
| 4,500' | 600,000 | 1,806 " |
| 4,200' | 500,000 | 1.505 " |
| 3,500' | 211,600 | 640 " |
| 5,600' | None, trolley only | |
| Average for each 1,000 ft. | | 1,275 lbs. |
| Average per mile | | 6,732 " |

LOCATION OF NEGATIVE TROLLEY: In changing over from single to double trolley system, the additional negative trolley base is ordinarily set about 18 inches ahead of the positive trolley base. However, a large number of cars are fitted with a combination base which is so designed as to hold both trolley poles. This makes a simpler and neater arrangement than where the trolley poles are placed in separate bases.

LIGHTNING ARRESTERS: The average spacing of the lightning arresters of the positive and negative feeders is 2,000 feet.

SPACING OF POLES: The poles are regularly spaced from 95 to 100 feet, center to center.

SUSPENSION CONSTRUCTION: A 5/16-inch diameter twisted galvanized iron wire cable is used for supporting the positive and negative overhead trolley wires.

TROLLEY WIRES: The positive and negative trolley wires are each 0000 gage, and regularly spaced 18 inches center to center.

TROLLEY WIRE HANGERS: Two general types of trolley hangers are in use. The first is simply the ordinary insulated suspension hanger connected directly to the cable without a strain insulator between the positive and negative hangers. In the second type three strain insulators are used. One of these insulators is placed between the positive and negative hangers and connected to the hangers with substantial iron links and pins; and then one strain insulator is placed between each hanger and its adjacent supporting cable. This is a more expensive but better type of construction than the first mentioned, and is used in the cost figures given in §425.

TROLLEY SWITCHES: With the double overhead trolley system it is not feasible to use frogs for the switching of the trolleys from one line to another, for the reason that it would be necessary for the positive and negative lines to cross each other under such an arrangement. In order to switch the cars, the men simply remove the two trolleys from the one line and place them on to the respective positive and negative wires of the adjacent line on which the car is to go.

**§421 Why Double Overhead Trolley System Was Installed.**—The first electric traction lines installed in Washington, D. C. were of the single trolley type, and, as a result, considerable trouble was experienced from the destruction of the District's underground water mains by the electrolytic action caused by the stray currents. As a result of this condition, when the later franchise grants were made they contained the following provision:

"Wherever the trolley system is used, a return wire, similar in capacity, situation, and installation, to the feed wire, shall be provided for the current, and each car shall be provided with a double trolley; and no dynamo furnishing power to the road, or any portion thereof, shall have either of its poles connected with the earth. All plans of location and construction shall be subject to the approval of the Commissioners of the District of Columbia."

**§422 Extra Maintenance Cost of Double Overhead Trolley System.**—The maintenance cost of a well-built double overhead trolley system is practically no more than that of a single trolley system. Of course the wear on the trolley wires is twice as great, but on account of the high price of scrap copper, even when it is necessary to replace the negative trolley line, the extra cost is small, and is not as great as the care and maintenance necessary with a bonded rail system.

**§423 Extra Maintenance Per Car.**—Practically the only additional wear on the car equipment is that of the trolley wheel on the negative trolley. The average distance traveled by a trolley wheel is 8,000 miles, and new wheels cost 65 cents. It is thus evident that the additional car maintenance cost is negligible.

**§424 Extra Installation Cost Per Car.**—This is as follows:

| | |
|---|---|
| Double trolley base, consisting of 2 poles, 2 harps and 2 wheels | $19.00 |
| Negative wiring of car and labor | 6.00 |
| Lightning arresters for negative circuit | 5.00 |
| Total extra cost for changing single trolley car so as to adapt it to the double overhead trolley system | $30.00 |

**§425 Extra Installation Cost Per Mile of Double Overhead Trolley System.**—On the basis of using a line that has a pole spacing of 55 poles per mile on each side of the street, and substituting a new cable suspension with new trolley hangers, trolley ears, and strain insulators, the average extra cost of the double overhead trolley system per mile will be approximately as follows:

| | | | |
|---|---|---|---|
| 3000′ | 5/16 Galvanized suspension cable | $30.00 | |
| 110 | Straight line hangers | 60.00 | |
| 20 | Curve hangers | 11.00 | |
| 130 | Trolley wire ears | 39.00 | |
| 195 | Strain insulators with pins and links | 87.00 | |
| 5 | Feed-in yokes | 2.00 | |
| 1 | Section insulator | 6.00 | |
| 55 | Negative feeder insulators | 3.00 | |
| 55 | Insulator pins | 1.00 | |
| 25 | Lbs. solder | 6.00 | |
| 3 | Lightning arresters | 12.00 | |
| Miscellaneous | | 5.00 | |
| | | | $262.00 |
| Labor | | | 150.00 |
| Negative trolley wire 0000 gage, 3,500 lbs. @ 16c | | | 560.00 |
| Negative feeder wire (See §420) 6,732 lbs. @ 16c | | | 1,077.00 |
| Average extra cost per mile of double overhead trolley system similar to that in Washington, D. C | | | $2,049.00 |

**§426 First Aim of All Remedial Measures.**—All remedial measures should have for their first aim the reduction of the drop in potential in the rails to a minimum, because this reduces the cause of the trouble. (140)

**§427 Adequate Rail Bonding.**—Adequate rail bonding necessitates making the return circuit of conductivity fully as great as that of the overhead supply circuit without relying upon any conductivity from the ground. Cast or welded rail joints are much more reliable than mere copper wires or bars around the rail joints.

**§428 Continuity of Return Circuit.**—The maintenance at all times of a continuous normal metallic return circuit is imperative, if stray currents are to be kept off of underground structures. Cast or welded rail joints make no provision for expansion or contraction and, as a result, the joints or rails frequently break in cold weather. Copper used for rail bonds or return circuits, when in contact with the earth, deteriorates very rapidly and soon becomes unreliable as a safe conductor. Hence, return circuits must be tested at frequent intervals in order that their continuity may be maintained continuously.

**§429 What Radial Return System Is.**—"In the radial return feeder system, the return feeders are designed to drain the rails of current at many selected points, leaving these points at the same potential, thus greatly reducing the rail drops and minimizing stray currents on underground structures." (188)

**§430 Requirements of Radial Return System.**—These may be summarized as follows:

1. "The most important step is to maintain the rails perfectly bonded, so that the tracks form continuous electrical conductors." (140)

2. "Limit the radius from the power station to which the station supplies electric power, so that the currents do not have to be returned from excessive lengths of rails to any one power station. This is usually accomplished in practice by supplying power to electric railways from distributed sub-stations." (140)

3. "Remove current from rails wherever there is concentration of current, by means of insulated return feeders." (140)

4. "The return feeders should be proportioned for constant drop, so that the rails at all points where return feeders are connected are maintained at substantially the same potential under average load conditions." (140)

5. "The rails immediately in front of the power station must not be connected directly to the negative bus-bar, unless a resistance

corresponding to the average resistance of the return feeders is connected in the circuit." (140

6. "The rails must not be bonded to any other underground structures." (91)

7. "The return conductors should have a cross-section at least equal to that of the outgoing conductors." (91)

8. "Each return conductor must be provided with either an adjustable resistance or a negative booster, so that the product of current and resistance may be made the same for all conductors." (91)

9. "By connecting a voltmeter, it must always be possible to determine the potential of all the points where return conductors are connected to the rails, and points of relatively highest potentials in the rail network." (91)

§431 Importance of Proper Copper Distribution in Radial Return System.—"The disposing of return feeder copper is quite as important as the weight of return feeder copper used. Where insulated return feeders have been installed, they have only in rare cases been properly proportioned for equal drop in potential." (91)

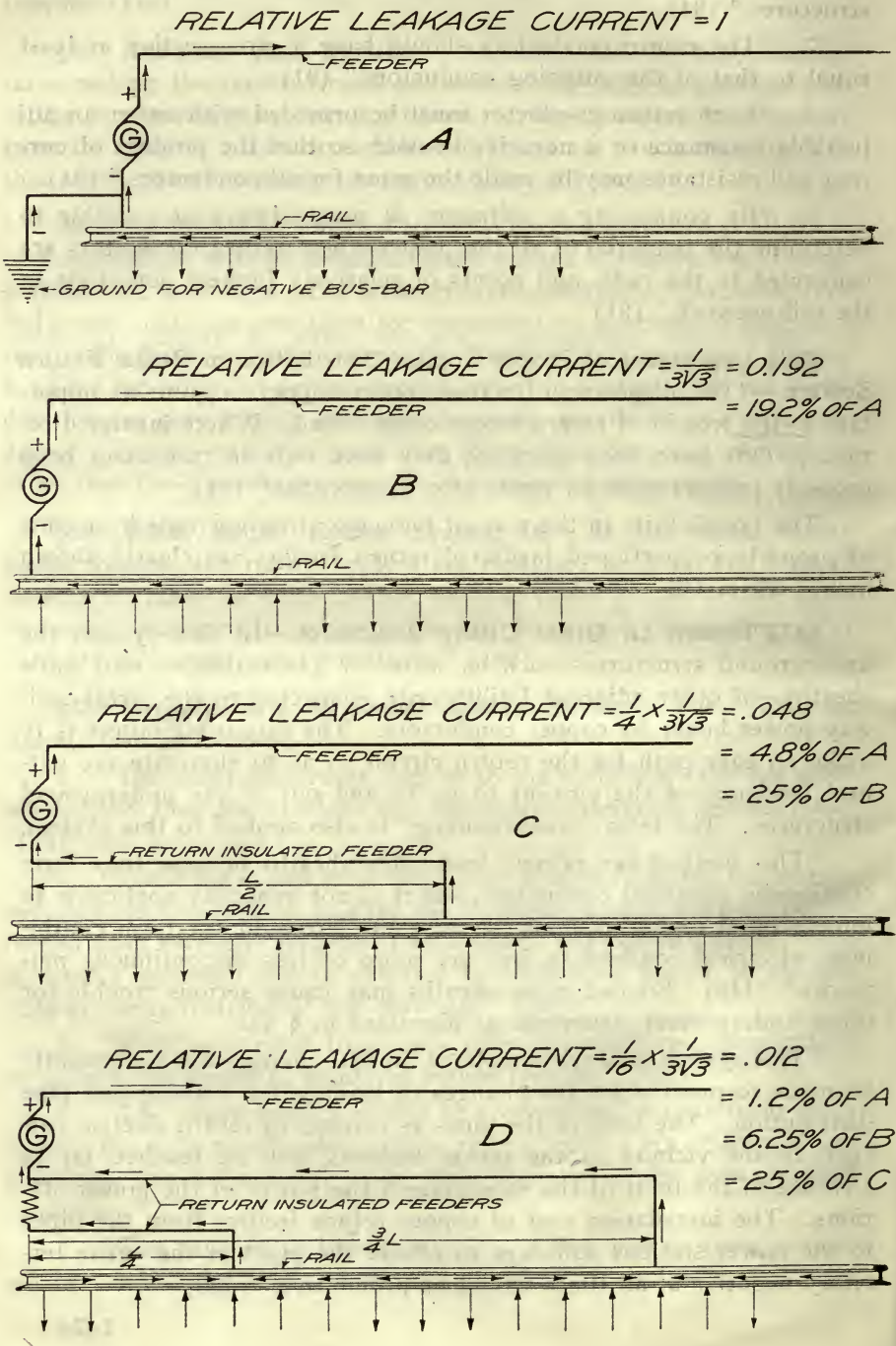
The possibilities in the way of reducing stray currents by means of properly proportioned insulated return feeders are clearly shown in Fig. 37, p. 148. (90, 140)

§432 Return on Other Utility Structures.—In this system the underground structures—such as water or gas mains or lead cable sheaths—of other adjacent Utilities are connected to the street railway power house by copper conductors. The ostensible object is to make an easy path for the return circuit so as to eliminate the natural tendency of the current to go in and out of the underground structures. The term "cross-bonding" is also applied to this system.

"This method can protect lead cable sheaths because they form continuous electrical conductors, but it is not generally applicable to underground piping systems, because the latter do not form continuous electrical conductors, but are more or less discontinuous networks." (140) Bonded cable sheaths may cause serious trouble for other underground structures as discussed in § 435.

"This system is never completed, in that changes must constantly be made to provide for the changes of loading, car routing and pipe distribution. The limit of the pipes as carriers of return electric current, in the vicinity of the power stations, will be reached far in advance of the limit of the extension of the power of the power stations. The installation cost of copper return feeders from the pipes to the power stations sufficient to render the pipes of the entire territory negative at all times would be prohibitive." (188)

# FIG. 37
# RELATIVE STRAY LEAKAGE CURRENTS WITH VARIOUS RETURN CIRCUIT CONDITIONS



**§433 Dangers in Return on Other Utility Structures.**—"Bonding of pipes to the rails or to the negative return circuit can afford only local protection to the extent that the piping connected forms a continuous metallic conductor, and this is an unknown and indeterminate quantity in a piping network." (140)

The practical working out of a bonding or drainage system results in the following:

1. "There is a reduction in the difference of potential between pipes and rails in the positive area, and consequent reduction of damage in those areas." (140)

2. "There is an increase of current flow on the pipes thruout the entire system, thus increasing the danger of trouble at high resistance joints." (140)

3. "As a rule, in the early stages of this system and especially in small networks when there are comparatively few bond connections and the resistances of the paths over the pipes are therefore relatively high, the effect is apt to be beneficial, reducing the danger in positive areas more than it increases the danger elsewhere." (140)

4. "As the load increases, more and heavier bonds become necessary and the current on the pipes may finally become so great that the trouble from current shunting around joints or between separate systems will increase more rapidly than the danger in the positive areas is reduced." (140)

5. "Since bonding transfers the trouble from the region where it is most evident to a new locality where it may require several years to manifest itself, the false impression is created that the trouble has been removed. It is due largely to the obscure manner in which trouble develops that this method has become quite widely used." (140)

6. "Bonding is like the drug habit, producing temporary relief at the expense of permanent and perhaps irreparable injury to the victim, which injury is, however, too rarely attributed to the true cause." (140)

7. "Bonding pipes as a means of protection always renders the bonded structures a part of the return circuit, and therefore a source of danger to other underground structures," (140) as cited in §432.

**§434 Damages Caused by Return on Other Utility Structures.**—"A number of cases have been reported where a main bonded to the negative return circuit at the power station was completely destroyed by electrolysis a block or two away because of a high resistance joint in the main, forcing current to shunt around the joint and leave the

main a short distance away from the power station. In one of these cases an entire block of main had to be replaced." (140)

**§435 Bonded Cable Sheaths Produce Dangerous Conditions for Other Underground Structures.**—"The bonding of telephone cable sheaths to railway returns has the effect of converting the cable sheaths into a part of the return circuit of the railway, and places them in the same relation as to electrolysis of pipes as the rails on the street, except to a far more dangerous degree, because the pipes are much closer to the cable conduits in the ground than they are to the rails—in many cases but a few inches apart, and in some cases resting directly against the conduit. Under such conditions where both metals are in a wet soil, a difference of a few tenths of a volt is often sufficient to carry current and cause damage to main or service pipes." (217)

**§436 Use of Underground Structures of Other Utilities for Return Circuit Is Saving to Electric Railway.**—"The leaking of current from the rails of electric railways, producing stray currents thru ground and underground structures, does not constitute a source of loss to the railway company, as, for instance, would be the case with leakage of gas or water. On the contrary, by allowing the current to return by ground and underground structures as well as by way of the rails, the total conductivity of the return circuit is increased, and the voltage loss in the return of this current is decreased, so that there is an actual saving of power for the railway company." (140)

**§437 Joint Insulation.**—"Insulating every joint or every few joints of a cast iron pipe line would, without doubt, render the pipe line of such high resistance that little, if any, return current would travel in a longitudinal direction, but would in no way prevent returning earth currents from passing from one side of the pipe to the other, causing an electrolysis of the pipe at the points where the currents leave the pipe for the earth." (188) Furthermore, the cost for most existing pipe systems would be prohibitive.

The following shows the effectiveness of joint insulation based on the average of eight tests, covering three months: (84)

Current in ordinary lead jointed line, .270 amperes.

Current in cement insulated jointed line, .009 amperes.

Ratio, Lead ÷ Insulation = 300.

"Joints designed and installed as insulating joints may or may not be insulating when completed, and this is especially true after the joints have been in service some time." (84)

"A little carelessness in making, or a slight settling of the main, may destroy the insulating features entirely and thus make the joint worthless." (84)

"No insulating joint will stop electrolysis in damp soil or in soil of the proper chemical condition that will allow the action to take place." (211)

**§438 Coating or Painting.**—"It is doubtful whether there is an instance in which it has been definitely proven that insulating paints have effectually protected pipes from electrolysis, while there are many instances where they have failed utterly and where their presence has probably done actual harm." (84)

"There are paints which are practically non-ionizable and such paints do prevent electrolysis where the underground structures are entirely coated, provided that such coating remains intact during the construction and repair of that structure and other adjacent structures—a condition that is practically impossible in our city streets. The coating of structures with cement and similar material must be discarded because of the expense, except in rare cases." (188)

**§439 Summary of Coating Situation (191).**—

1. Paints as a rule do not prevent electrolysis, but some doubtless have a beneficial effect in curtailing soil corrosion.

2. The appearance to the naked eye of a paint film is no indication of its permeability to water.

3. Corrosion of metal may take place beneath a pain film without affecting the appearance of same.

4. The metallic body, before being covered, must be smooth and free from rust, moisture, loose scale and foreign matter in order that it be preserved.

5. In general, dips applied hot are better than paints, and probably furnish the key to the solution of the prevention of corrosion.

6. Concrete of itself is not an efficient protection against electrolysis.

7. Wrapping materials in general add nothing directly to the insulative character of a given coating.

**§440 Relative Electrolytic Activity of Alternating and Direct Current.**—"Tests indicate that the electrolytic action of alternating currents will corrode both electrodes, but will be only a small fraction of that produced by direct current. However, it is not safe to assume that the substitution of alternating for direct currents on single trolley roads would eliminate electrolytic troubles." (81)

"Alternating current electrolysis is not a phenomenon like direct current electrolysis, on which definite quantitative laws can be formu-

lated, but is of the character of a secondary effect, rarely exceeding one-half per cent of the electrolytic action of direct current." (88)

**§441 Relation of Electrolyte and Alternating Current Electrolysis.**—"Alternating current electrolysis, when quantitatively, or in per cent, of the action of an equal direct current, varies very greatly with the chemical character of the electrolyte. The nitrates and similar compounds, as fertilizers, tend to increase the electrolytic corrosion; carbonates and, in general, alkaline reactions of the soil decrease the corrosion." (88)

**§442 Relative Alternating Current Electrolytic Activities of Lead and Iron.**—"In general, lead is more attacked than iron and the latter shows still more erratic behavior than lead." (88)

**§443 Relation of Frequency to Corrosion.**—"In general, electrolytic corrosion by alternating currents increases with decrease of frequency. This increase with decreasing frequency does not follow a general law but depends largely upon the chemical character of the electrolyte. It may be enormous; that is, 25 cycle current gives many times greater corrosion than the same current at 60 cycles. Or it may be very small and negligible." (88)

"In some instances 60 cycle current seems to give a somewhat greater attack than 25 cycle current." (88)

**§444 Electrolysis of Iron and Steel in Concrete.**—The known facts may be summarized as follows: (89)

1. "Steel structures are well preserved from ordinary corrosion by concrete if placed either in salt or fresh water."

2. "If but a small fraction of an ampere of electricity passes from an interior metallic structure into concrete or masonry as usually made, there will be corrosion of the metal and disintegration of the concrete or masonry."

3. "Structures of steel in concrete that are subject to sea water are in more danger from electrolytic action than those in fresh water, by reason of the lower resistance of concrete in sea water."

4. "In no sense can concrete be considered an insulator, and it is from all appearances just as good an electrolyte as any of the soils found in the earth."

5. "It is a false reliance to consider that masonry, mortar, concrete, or cement are impervious to moisture and incapable of acting as an electrolyte such as would induce electrolysis. They are not insulating substances, or at the best only in the smallest degree under the most favorable circumstances. They are positively porous and

in nearly every case, whether tested in large or small mass, are permeable to all waters or moisture and gases, and in but a few exceptional cases ever become thoroly dry."

6. "So long as the single trolley with its grounded return is in general use, just so long may we look for electrolytic action in some form upon various underground structures; and reinforced concrete is no exception to the rule."

**§445 Electrolysis Survey.**—The object of a survey is to indicate the existence or non-existence of stray electric currents on underground structures, and to determine where such currents flow onto and from the underground structures. To be of value the survey must consider the following:

1. Voltage.
2. Current.
3. Direction of current.
4. Variation in current flow.
5. Location, whether on a level, approach, slope or brow of hill.
6. Moisture conditions, whether structures are above or below water level.
7. Nature of soil, whether natural or filled.
8. Composition of soil.
9. Temperature of soil.
10. Density of traffic on street railway.
11. Negative feeder layout.
12. Type and efficiency of rail bonds.
13. Interrelation of other underground structures.

**§446 Electrolysis May Cause Secondary Corrosion.**—"A number of experiments made have clearly shown that, even when current leaves iron for street soil at an extremely low density, corrosion is produced which is frequently greater than the theoretical amount. This increase of the actual over the theoretical amount is undoubtedly due to secondary chemical reactions set up by the action of electrolysis." (140)

**§447 Fire Hazard Due to Electrolysis.**—"Stray currents, where they flow on underground piping systems, frequently enter buildings thru service connections and produce a serious fire hazard. For example, current may flow into a building thru a water service pipe, then flow from the house water piping to the house gas piping, and then out from the building thru the gas service pipe. Such contacts between service pipes or between a service pipe and the lead sheath-

ing of a telephone or a power cable frequently occur thru metal ceilings, or where the pipes rest against each other. Since dangerous heating may be produced where the current flows thru such contacts or where vibration may momentarily separate the contacts and produce an arc, near-by inflammable material is in danger of being set on fire." (140)

"Many cases have been found where currents up to 30 amperes were flowing into and out of buildings thru service pipes or lead cable sheaths. Evidences of arcing having occurred between such contacts in buildings have also been found. There is no doubt that many fires have started in this way, but it is always difficult to prove the cause of a fire because of the destruction resulting from the fire." (140) See §158.

**§448 Indirect Damages Due to Electrolysis.**—These are as follows:

1. Loss of water due to leakage.
2. Flooding other property from broken water mains.
3. Injury to consumer from shutting off of water service.
4. Loss of gas due to leakage; see §158.
5. Gas explosions resulting from leaks.
6. Injury to consumer from shutting off of gas service.
7. Interference with telephone, telegraph or other electrical service due to injury to lead cable sheaths.
8. Aiding secondary corrosion; see §466.
9. Starting fires due to arcing of stray electric currents on building fixtures.
10. Corroded water mains failing at a critical time for fire fighting service.

**§449 Direct Damage Due to Electrolysis.**—This is the injury or destruction of underground structures such as heating, cooling, gas and water mains, telephone, telegraph or other electrical cable sheaths, reinforced concrete, and fixtures electrically connected to such structures.

He who has suffered damage has
a right to demand satisfaction.
—J. Locke.

# Chapter 10

## LEGAL STATUS OF ELECTROLYSIS

**§450 Electrolysis Before the Courts** (38).—The dicta laid down by the courts in the comparatively few cases that have been decided are given in this chapter and shown in co-ordinated form in Fig. 38, p. 156.

**§451 Primary Purpose of Streets.**—"The primary and dominant purpose of a street is for public passage, and any appropriation of it by legislative sanction to other objects must be deemed to be in subordination to this use, unless a contrary intent is clearly expressed." (590)

**§452 Utilities That Are a Burden.**—The placing of pole lines on and along streets "is not using the streets for one of the purposes to which they have been dedicated as public highways." (590) Hence, such lines are a burden and are "subordinate in all respects to the rights of public travel." (590)

**§453 Utilities That Are Not a Burden.**—An electric street railway is not a burden since "it occupies the streets in such a manner as to expedite travel and promote the public use to which the streets were originally devoted." (590)

"With rare unanimity the courts have concurred in holding that an electric street railway, constructed and operated upon the streets, by means of an overhead trolley wire supported by poles, and conforming its track to the surface of the ground, is not an additional servitude upon the fee within the streets, but a legitimate use of the streets within the original general purpose of their dedication." (615)

Any Utility having its wires or mains underground, so as not to interfere with the surface use of the street for travel, is not a burden on the street, and is protected by the doctrine stated in §455.

**§454 Priority.**—"There is no question of prior equities involved. It is a matter of strict legal right. Neither priority of grant nor priority of occupation can avail either party." (590)

**§455 Relative Rights.**—"The laying of water pipes under ground is much less of an obstruction and interference with the ordinary purposes of a street than the laying and maintaining of a railway track

# FIG. 38
# FACTORS PERTAINING TO ELECTROLYSIS DAMAGES

1- STREETS
- PRIMARY PURPOSE OF
- UTILITIES THAT ARE
  - A BURDEN ON
  - NOT A BURDEN ON
- PRIORITY
- RELATIVE RIGHTS
- MUTUAL RELATIONS

2-DAMAGES
- LIABILITY LIMITED TO NEGLIGENCE
- EXTENT
- FRANCHISE DOES NOT AUTHORIZE
- CAUSE
- NEGLIGENCE
- DUTY TO PREVENT
- STRAY CURRENTS DO NOT ALWAYS PRODUCE

3- COURT
- CANNOT
  - SPECIFY PLAN OF RELIEF
  - STOP OPERATION OF RAILWAY
- LIMITED TO ENJOINING CONTINUANCE OF INJURY

upon its surface. It cannot be held that the use of a street for water pipes is in any sense subservient to the use for electric street railway purposes, assuming that both uses have been granted by the municipality in the proper exercise of its authority." (540)

"The use of the streets for water works purposes is obtained by legislative authority. The right of an electric railway to use the streets is from like authority. Each of these uses is beneficial to the public and each is entitled to use its respective rights, without interfering with the other, and it is clear that no conflict can occur between the two if each would remain within its own sphere and exercise its powers with due care and prudence. It is not necessary in arriving at a proper decision in this case to determine which should give way to the other. Both are legal, and both are important and of almost equal necessity to the inhabitants of the city." (596)

**§456 Mutual Relation.**—In the case of two Utilities, one legally occupying the surface of the street and the other legally having property under the street, if one injures the other, "both are entitled to the equal protection of the laws against the invasion of their rights and property by others." (540)

"Each should exercise its function for the general good, exercising due care not to interfere with the duties and rights of the other." (596)

**§457 Liability for Damages Limited to Negligence.**—"A street railway operated with a single trolley system, under a franchise granted by the municipality, is liable only for damages from its actual negligence in the use of such system." (596)

**§458 Extent of Damage.**—"The injury done to mains by electrolysis is not a mere incidental injury or inconvenience, but is a permanent, continuing injury to a legal right, which will in effect, if the injury is permitted to go on, ultimately result in the absolute destruction of property." (540)

**§459 Franchise Does Not Authorize Damage.**—"The license which grants the right to lay tracks and propel cars by electric motive power does not assume to give the 'right' to construct and operate so as to damage the property of others." (540)

**§460 Cause of Damage.**—"The injury complained of is the direct and immediate result of defendants' acts, as much so as if the defendants were to uncover deliberately and destroy by any other means the mains of complainants." (541)

**§461 Negligence.**—"The defendants, by taking necessary, reasonable precautions in operating their railways, would be able to avoid

the injury, and, this being true, their failure to take such precautions must be considered as negligence." (541)

**§462 Duty to Protect Against Electrolysis.**—"The complainant is as much entitled to protection against the injury from defendant's electric currents, negligently allowed to stray upon its property, as it would be to protection from the wanton destruction of its property by any other direct means which might be employed by the defendant." (541)

**§463 Stray Currents Do Not Always Produce Electrolysis.**—"The statement that 'a difference in potential of a fraction of a volt may cause electrolysis' is sometimes true and sometimes not, but as applied to a general system of water pipes it is utterly untrustworthy. Electrolysis is a question of surrounding conditions, and the current leaving a pipe may or may not be attended with injury to the pipe." (544)

**§464 Court Cannot Specify Plan of Relief.**—"The court has no power to prescribe by injunction the use of any particular system of circuit or negative return. That no specific system can be imposed by the court is settled by general decisions, passing on the essential distinction between legislative and judicial power." (542, 543)

**§465 Operation of Railway Cannot Be Enjoined.**—"It is doubtful whether the judicial power would extend to the making of a decree restraining the defendant from continuing to serve the public unless it shall cease injuring complainant's water system." (542)

**§466 Remedial Action.**—"The injury resulting from electrolysis is actionable; there can be no doubt of the power of the court to grant some remedy. The damage already done is chargeable to the defendants, and, so far as such damage is capable of being definitely ascertained, the defendants should be held liable in a suit at law." (541)

"Defendant should be enjoined from continuing the injury to the complainant's water mains and service pipes and should be given a reasonable time to take such measures as will substantially prevent injury." (545)

"The defendant's whole duty is to make the damage as little as possible by using the best means reasonably within its power, the selection of such means to be left to its discretion and at its peril of failure to exercise such discretion in a fair, bona fide way." (543)

The administration of justice is the chiefest concern of man.
—Daniel Webster.

# Chapter 11

## VALUATION

**§467 Object of Valuations** (108).—Valuations are usually made to secure data as a basis for one of six purposes:

1. Negotiate loans.
2. Secure additional vested rights.
3. Taxation.
4. Limitation of capitalization.
5. Rate regulation.
6. Fixing price for sale.

**§468 Purpose of Valuation.**—The purpose of the valuation may determine the method of making it. The sole test is that the valuation shall be just, equitable and reasonable to both the Public and the Utility. Thus there is no inconsistency in using different valuation methods for taxation, rate regulation or purchase cases.

"With reference to taxation values, the Utilities are entitled to earn and to pay to the State whatever assessment is made against them, no matter on what method the assessment may be made, and the amount paid must be allowed to them just as the cost of operation is allowed to them; but on the other hand the taxation value is not the value upon which to base the rate." (660)

"The valuation placed on Utilities depends, to some extent at least, upon the purposes for which it is intended. For instance, in valuing Utilities for the purpose of condemnation and purchase, many elements must often be taken into account which should not be given any consideration in valuations made for the purpose of rate making." (731)

**§469 Distinction Between Arbitration and Appraisal.**—This is clearly defined. "An arbitration is a reference to the decision of one or more persons, either with or without an umpire, of some matter or matters in difference between the parties." (500)

"When parties have agreed that one should sell and the other buy a specific thing, and the price should be a valuation fixed by persons agreed upon, it cannot be said that there was any dispute or

difference. Such an agreement precludes or prevents difference, and is not intended to settle any which has arisen. This seems to be the distinction between an arbitration and an appraisement, though the first term is often used when the other is more appropriate." (499)

**§470 Distinction Between Public and Private Concern.**—"When a matter of purely private concern is submitted to the determination of either arbitrators or appraisers, the rule seems to be that there must be unanimity of conclusion by such board, unless otherwise indicated by the terms of the submission." (498)

"The rule is, however, otherwise when the submission is one which concerns the public. In such submissions, whether it be the arbitration of a difference or the ascertainment of a value, a majority may act, unless otherwise indicated by the agreement for submission Why this distinction should exist is not altogether clear. In both instances the persons to whom the submission is made are acting under a power and must stay within it. The reason probably lies in the fact that public affairs are controlled by majorities, and, by analogy, a majority should control when the submission is a matter which concerns the public. But whatever the reason, so are the authorities." (498)

**§471 Judicial Procedure Not Necessary in Appraisal.**—"In an appraisement, the strict rules relating to arbitration and awards do not apply. The appraisers are not rigidly required to confine themselves either to matters within their own knowledge or those submitted to them formally in the presence of the parties, but may reject, if they see fit, evidence so submitted, and inform themselves from any other source, as experts who were at last to act upon their own judgment." (501)

**§472 Methods of Making Valuations.**—These may be classified as follows:

1. Cost of reproducing similar plant, less depreciation of existing structures and materials.
2. Original cost, less depreciation.
3. Cost of reproducing such parts of established plant as can be embodied in new and modern system, less depreciation.
4. Combined market values of all securities.
5. Capitalizing earnings.

**§473 How Reproduction Cost Is Ascertained.**—All the various elements of the investment, from the inception of the idea to the completed and profit-earning plant, are developed step by step. The logical order for a typical Utility is shown in Figs. 40, p. 182, and 41, p. 187.

Great care is imperative in selecting the proper unit prices—see §494—and insuring that all proper items are included; see §493. Errors of omission are more probable than errors of commission.

Excluding abnormal or unusual cases, the point of view that will usually be fairest to both the Public and the Utility is to figure the cost of reproduction under the actual physical, commercial and economic conditions prevailing when the plant was originally built. "The appraiser must base his appraisal on the actual conditions under which the property was built and operated. If money was spent to educate the public to the use of the service sold by the Utility, then that money is a development expense which must be allowed, even tho the expense would not now be incurred by a new Utility. In brief, the entire history of the Utility must come within the appraiser's knowledge and consideration." (108)

**§474 Judicial Recognition of "Reproduction Cost."**—In the following cases reproduction cost is held the controlling basis of value for rate regulation: (480, 514, 525, 535, 546, 587, 600.)

**§475 Invested Dividends Must Be Considered.**—"In determining the investment, it is not necessary that money should first be paid to the stockholder and then returned by him in payment for new stock issued to him. The net earnings, in equity, belonged to him, and stock issued to him in lieu of the money so used that belonged to him was issued for value, and represents an actual investment by the holder." (607)

**§476 Factors Having a Direct Bearing on Valuation.**—

1. Cost to reproduce physical property. (480)
2. Cost to reproduce intangible property. §480.
3. Combined market value of securities. (525)
4. Going value. §536-551.
5. Going concern value in purchase cases. §557.
6. Franchise earning value in purchase cases. (525)
7. Piecemeal construction cost. §503.
8. Relation of present service to value. §498.
9. Working capital. §504.
10. Allowance to meet annual depreciation. (480, 523, 524)
11. Current repairs. (462)
12. Taxes. (462)
13. Managing expenses. (462, 464)
14. Value of part not taken in damage cases. §524.
15. Invested dividends. §475.

**§477 Factors Having Only Secondary Bearing on Valuation.—**

1. Interest rate. (514)
2. Amount of outstanding stock. (480)
3. Amount of outstanding bonds. (575)
4. Value assessed for taxation. (518)
5. Original cost. (523)
6. Purchase price from former owner. (597)
7. Financial losses. (515)
8. Property destroyed by Utility's negligence. §330.
9. Good will. §520-523.
10. Value of land for other than Utility purposes. (528)

**§478 Factors Having No Bearing on Valuation.—**

1. Past service. §499.
2. Paving not paid by Utility. §501.
3. Complete and incomplete depreciation. §500.
4. Amount of outstanding stock in rate cases. §269.
5. Amount of outstanding bonds in rate cases. §268, §495.
6. Going concern value in rate cases.
7. Franchise earning value in rate cases. §519.
8. Good will in case of monopoly or in rate cases. §521, §523.

**§479 Overhead Charges.**—This is a generic or blanket expression to cover the various species of intangible property as itemized in I, 1, A of Fig. 41, p. 187. Much more satisfactory and accurate results will be obtained if each species of intangible property is valued by itself, rather than to attempt to cover them all by a lump sum.

**§480 Intangible Property Must Be Valued.**—It may appear strange to consider intangible property—something we cannot feel, see or perceive with the physical senses—as a part of the total investment. However, no plant can be built without incurring these expenses and they must therefore be included in the total cost or investment. What they embrace is indicated on Figs. 41, p. 187, and 42, p. 188, and they are discussed in §481 to §488.

"We must avoid the fallacy that only the physical portion of a corporation's property is entitled to a value, a fallacy which has led many engineers, many business men and many corporations to disaster, the facts being that beyond the naked physical value there is required a very large and material sum to change that naked inert mass of physical construction into a live, progressive, earning entity. The omission of the cost of making a going concern in addition to its naked physical value has been the root and cause, in my judgment, of a large proportion of the disasters which have overtaken enterprises in the field in which we operate." (99)

"There are certain expenses connected with every undertaking which are not represented by physical property but which must be incurred before the plant is operated." (683)

**§481 Promotion Cost.**—Successful promotion requires optimistic forethought, business sagacity, broad perspective, visions of future possibilities, and, in all cases, ability of the highest order. It is therefore but fair that proper compensation be made for such pioneer service.

"The honest services of a capable promoter are indispensable to the flotation of every comprehensive and far-reaching scheme of development. A clear vision to see opportunities, ability to demonstrate them to others, and energy to push to completion works untried, but of great moment, are indispensable to material development and should be fairly and even liberally rewarded by the public which receives the benefit of those works. Such rewards are to be treated simply as just payments for valuable and in many cases indispensable services performed for the Utility." (686)

**§482 Bond Discount as an Interest Rate Element.**—Few people appreciate the marked effect that bond maturity has on net interest rates when the bonds are sold at a discount. This relation is shown in the following, which indicates the prices that 5% and 6% bonds of maturities from 5 to 50 years must be sold for, to yield various net interest rates:

| Interest Rates | | | Prices at Maturities from 5 to 50 Years | | | | |
|---|---|---|---|---|---|---|---|
| Face Value | Net | | 5 | 10 | 15 | 20 | 25 |
| 5% | 5% | @ | 100 | 100 | 100 | 100 | 100 |
| " | 5.5% | @ | 97.84 | 96.19 | 94.94 | 93.98 | 93.25 |
| " | 6% | @ | 95.73 | 92.56 | 90.20 | 88.44 | 87.14 |
| " | 6.5% | @ | 93.68 | 89.10 | 85.76 | 83.34 | 81.59 |
| " | 7% | @ | 91.68 | 85.79 | 81.61 | 78.64 | 76.54 |
| 6% | 6% | @ | 100 | 100 | 100 | 100 | 100 |
| " | 6.5% | @ | 97.89 | 96.37 | 95.25 | 94.45 | 93.86 |
| " | 7% | @ | 95.84 | 92.89 | 90.80 | 89.32 | 88.27 |
| " | 7.5% | @ | 93.84 | 89.58 | 86.63 | 84.59 | 83.17 |
| " | 8% | @ | 91.89 | 86.41 | 82.71 | 80.21 | 78.52 |

| Interest Rates Face Value | Net | | Prices at Maturities from 5 to 50 Years 30 | 35 | 40 | 45 | 50 |
|---|---|---|---|---|---|---|---|
| 5% | 5% | @ | 100 | 100 | 100 | 100 | 100 |
| " | 5.5% | @ | 92.69 | 92.27 | 91.95 | 91.70 | 91.51 |
| " | 6% | @ | 86.16 | 85.44 | 84.90 | 84.50 | 84.20 |
| " | 6.5% | @ | 80.31 | 79.38 | 78.71 | 78.22 | 77.87 |
| " | 7% | @ | 75.06 | 74.00 | 73.25 | 72.72 | 72.34 |
| 6% | 6% | @ | 100 | 100 | 100 | 100 | 100 |
| " | 6.5% | @ | 93.44 | 93.13 | 92.90 | 92.74 | 92.62 |
| " | 7% | @ | 87.53 | 87.00 | 86.63 | 86.36 | 86.17 |
| " | 7.5% | @ | 82.20 | 81.52 | 81.05 | 80.73 | 80.50 |
| " | 8% | @ | 77.38 | 76.61 | 76.08 | 75.73 | 75.50 |

A common fallacy is to assume that if a Utility sells 5%, 20 year bonds at say 93.98, its credit is on a 5.5% basis and that 5.5%, 20 year bonds could be sold at par. This is correct, as far as the mathematics is concerned, but all wrong as far as the actual business end is concerned. Men financing Utilities are governed by market conditions rather than academic deductions, and always find that they can secure a larger amount of actual cash with a given annual interest allowance when bonds are sold at a discount than when they are sold at par.

**§483 Bond Discount as a Brokerage Commission.**—This may be defined as "the expense necessary to be paid a reputable broker for making a full and complete investigation of an inviting Utility enterprise and a reasonable compensation for inducing his clientage to invest in securities of such Utility."

**§484 Bond Discount as a Promotion Fee.**—In many cases the bond discount is part of a promotion fee to the men who underwrite the securities and thus make the financing of the Utility possible. See left hand side of Fig. 40, p. 182.

**§485 Liquidation of Bond Discount.**—It is evident that bond discount—regardless of what the discount may have been used for—is a liability that must eventually be met when the bonds are retired. Therefore, provision must be made to pay the full face value of the bond. In this way the element of bond discount is automatically liquidated with the original cash equivalent realized from the sale of the bonds.

**§486 Organization Cost.**—Just as soon as the permanent organization is completed it will be necessary to provide for its operation until the completed plant is ready for business. Executive, engin-

eering and legal expenses are absolutely necessary. It will also be desirable to carry insurance for the proper protection of the investment in physical property, to provide for compensation in case of injury to workmen, and to insure against moral turpitude of trusted employes. Office expenses will also be necessary, and certain contingencies due to unforeseen difficulties must be provided for.

**§487 Interest During Construction.**—"Interest during the period of construction must be paid, and as there are no earnings, it must be included as a part of the cost of the undertaking." (683)

"There is no doubt that interest at a fair rate on the capital invested, that remains idle during construction, is a part of the construction cost." (553)

"When the present value of a Utility is being ascertained for the purpose of determining what amount the Utility is entitled to earn as a fair return upon its investment, a reasonable amount for interest on the capital invested in the plant during period of construction should be allowed." (600)

If the securities for financing have been sold at a discount, the interest must of course be computed on their face value, and not on the amount actually realized from their sale.

**§488 Taxes During Construction.**—"Taxes during the period of construction must be paid, and as there are no earnings, they must be included as a part of the cost of the undertaking." (683)

**§489 Engineering Estimates.**—"It is extremely rare for a professional engineer or constructor in any branch of industry, in any branch of construction, to estimate the cost of such construction with accuracy, and the practically uniform experience has been that all such estimates have proved woefully less than the cost of the completed project." (99)

"How careful, therefore, how fair minded and liberal should be the point of view of the professional engineer in appraising the value of another man's or another corporation's property for the solemn and serious purpose of having based upon his appraisal the return which that man or that corporation is to be allowed to receive upon his investment. It is unfair that an engineer or appraiser, who recognizes at the bar of his own conscience that his own estimates have been uniformly overrun, should make his appraisals without taking into consideration and manfully applying to his estimate his own factor of individual inaccuracy, his own personal factor of nearly unfailingly underestimating." (99)

**§490 Post-Construction Estimates.**—"There is a vast difference in estimating the cost of an engineering work already completed and one which has yet to be started, the difference being largely in favor of a closer estimate of the completed work." (108)

**§491 Fluctuation of Prices.**—Prices for materials entering into Utility plants fluctuate thru a large range. Two typical cases are illustrated in Fig. 39, p. 167, which shows the variations in prices of cast iron pipe and ingot copper for twenty-six years.

**§492 Reconstruction Cost and Service Value.**—"The service value of a Utility plant may be as great when the cost of reconstruction is low as when it is high. This is an element that should not be eliminated in weighing the various factors that must be considered in making the ultimate deduction as to the fair value of the physical structure as a whole." (719)

**§493 Importance of Proper Unit Prices.**—"The general reliability of the appraisal rests very largely on the reasonableness and fairness of the various prices which are applied to the different parts of the property in making the estimate of cost of reproduction. These unit prices should be determined before any actual figures are made. They should be made up from the most complete data available, and then, before being tabulated, should be carefully reviewed by all the experienced men engaged on the appraisal, in order that no figure which is either too high or too low may be used." (108)

**§494 Proper Unit Price Requirements.**—This must:

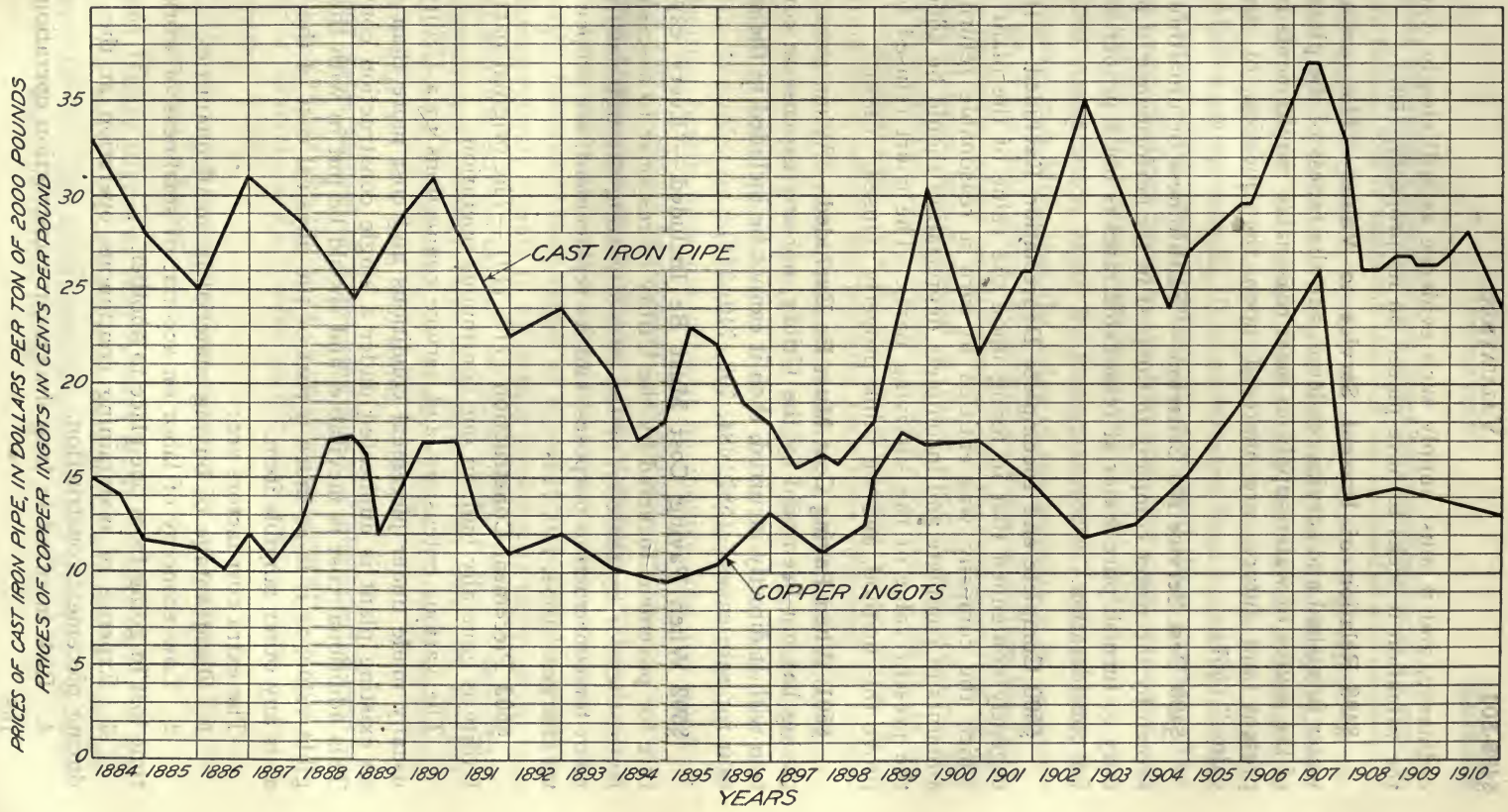
1. Represent fair average conditions covering the total range of market prices.
2. Consider all the construction conditions related to the plant.
3. Be large enough to cover the true investment represented in the property under appraisal.

**§495 Bonded Indebtedness Not Controlling.**—"In determining what are reasonable rates it is perfectly immaterial whether the Utility is mortgaged two or three times what it would cost to reproduce it, or whether it is free from incumbrance. To hold otherwise would be to hold that the public has indirectly guaranteed the payment of the mortgage bonds of every Utility." (575)

**§496 Taxation Values Not Conclusive.**—The sworn return of taxable property has been held not to estop the Utility from showing higher value in disputing the reasonableness of rates. (518)

**§497 Burden of Proof on Utility.**—The Utility has the burden of proving the valuation of its property to show the invalidity of the

# FIG. 39
# FLUCTUATIONS OF CAST IRON PIPE AND COPPER INGOT PRICES



ordinance, and it must supply such evidence as will clearly warrant the valuation it seeks to have placed on its property. (597)

**§498 Relation of Present Service to Value.**—"The quality of water furnished and service rendered, and the fitness of the plant and of the source of water supply to meet reasonable requirements in the present and future, are material upon the question of present value." (567)

**§499 Past Service No Criterion.**—"Faithfulness or unfaithfulness shown by the water company in the past in the performance of public duty to furnish pure water at reasonable rates is not a proper matter for consideration." (568)

**§500 Complete and Incomplete Depreciation Excluded.**—"It was urgently contended that in fixing upon the value of the plant upon which the company was entitled to earn a reasonable return, the amounts of complete and incomplete depreciation should be added to the present value of the surviving parts. The court refused to approve this method, and we think properly refused." (482)

**§501 When Paving Cost Must Be Excluded.**—"When the cost of paving has not been paid by the Utility, nor any expense in connection with it directly incurred, then it cannot be included in the valuation for rate cases." (587, 684, 708, 710, 724)

**§502 When Paving Cost Must Be Included.**—"Every expenditure for pavement incurred by the Utility in response to assessments levied therefor by the city, or the cost of cutting through such pavement for construction purposes, and its replacement, are proper capital charges." (684, 710, 724)

**§503 Piecemeal Construction** (710, 719).—The original part of a Utility is generally built in one continuous operation.

The various extensions and service connections to a Utility are usually made under piecemeal conditions and cost more than when an existing plant is duplicated under a single construction contract. This additional cost is inevitable, and should be put in with the tangible value, as it is as much a part of the physical cost of the plant as is any other tangible item.

The extra cost factors are:

1. Disadvantage of buying material in small quantities.
2. Low economy of labor on account of smallness of work and time lost in going from one place to another.
3. Expense of maintaining continuous operation at the plant during piecemeal construction.
4. Risk involved in long drawn out construction operations.

**§504 Working Capital.**—This must be considered and allowed in all rate cases. "It is apparent that for the successful and economical operation of the plant a certain amount of working capital is required." (510) "Utilities must purchase materials and supplies, must pay their employes and must render their service to consumers in advance of payment for such service. This requires a fund ordinarily called working capital. It is reimbursed from operating receipts from time to time, but originally is provided from capital. The amount needed depends upon the advances that must be made and the period for which they must be carried." (601, 683)

**§505 Appreciation Must Be Recognized.**—"We concur with the court below in holding that the value of the property is to be determined as of the time when the inquiry is made regarding the rates. If the property, which legally enters into the consideration of the question of rates, has increased in value since it was acquired, the company is entitled to the benefit of such increase. This is, at any rate, the general rule. We do not say there may not possibly be an exception to it, where the property may have increased so enormously in value as to render a rate permitting a reasonable return upon such increased value unjust to the public. How such facts should be treated is not a question now before us, as this case does not present it. We refer to the matter only for the purpose of stating that the decision herein does not prevent an inquiry into the question when, if ever, it should be necessarily presented." (492)

**§506 Difficulties of Equitable Land Valuation.**—"The study of values for taxation and rate-making has brought into prominence the perplexing features of land values as applied to corporation property. It is comparatively simple to fix within close limits the reproduction cost of physical structures, but not so with the land. A few years' development may change farm land right-of-way into city right-of-way, surrounded by factories, or it may change desirable residential property adjacent to a road into slums." (108)

**§507 Sales Method of Appraising Land.**—"The sales method consists of a study of the transfers of neighboring property having conditions or characteristics similar to the land whose value is to be determined." (710)

To be of value it must either consider or be corrected for the factors discussed in §508 to §514.

**§508 Utility Rights of Way Always High.**—Utility rights of way always cost much more than similar acreage of adjacent or contiguous farm lands. The actual purchase costs will generally be from two to five times the normal prices.

A Utility right of way must be continuous and located to suit the operating conditions of the Utility, and not the convenience of the adjacent land owners. This gives ground for consequential damages and, combined with the prevailing hold-up tendency, produces the high costs.

"A farmer is justified in increasing his price per acre by reason of the fact that the Utility must have a continuous line, regardless of how it affects the individual. He must rearrange his fields, change his fences, ditches and tile lines, and readjust his entire property to accommodate the necessity of the Utility. He must also take into account severance or damages." (108)

**§509 Factors Controlling Land Valuation.**—Equitable land valuation must consider:

1. Strategic position.
2. Method of acquiring.
3. Amount needed.
4. Use.
5. Basis of value.

**§510 Strategic Position.**—Correct location will result in a growing strategic advantage that will increase as the plant is developed. This is especially true if land needed for future extensions is acquired at the start, so that its appreciation, due to the location and strategic position of the Utility, will accrue to the Utility rather than to others who might be able to retard the normal Utility growth—or increase its investment abnormally, thereby unduly burdening future service users—by demanding exorbitant prices for such land when its acquirement became necessary. See §512.

**§511 Method of Acquiring.**—Practically all land for Utility purposes costs more than it was originally worth for other purposes, on account of the universal tendency of land owners to use "hold-up" tactics in dealing with Utilities. This is especially marked for those Utilities that have not been given the right of eminent domain.

**§512 Amount Needed.**—"Prudent management may require that land shall be purchased in advance of actual needs, for it may be clearly impossible to secure adjacent property just as it is needed at reasonable terms. Upon the other hand, it would be unwise for a Utility to speculate in land and call upon the service users to pay its losses." (684)

**§513 Relation of Land Use and Value.**—"The value of the land depends largely upon the use to which it is put and the character of the improvements upon it." (384)

"The measure of the value of real estate is its market value for its most available use." (552)

**§514 Basis of Value.**—"The value to be taken is the present fair value. It would be unfair to take boom figures, and it would be equally unfair to fix the price at what the property would bring at forced sale." (684)

"On the question of the value of a large tract of land, evidence of the price paid for portions of the tract recently purchased is admissible." (558)

**§515 Rates May Not Be Increased Merely Because Land Values Have Increased.**—"Whatever the true economic or legal view may be as to the right of a carrier to consider the increase in value of its land as a part of the value upon which it is entitled to a reasonable return, such increase in value does not of itself establish the right of a carrier to increase rates upon a given service. Certainly it is a conservative statement of the law to hold that a railroad may not increase the rates upon a number of commodities solely because its real estate has risen in value." (659)

**§516 Franchise Rights Must Be Considered.**—"A franchise is property and subject to all the rules of property." (291)

"Franchises, easements and the ability to use property, tho intangible, have value, and are equally with tangible property entitled to the recognition and protection of the courts." (616)

"The idea that a valuable franchise could be taken in condemnation proceedings without compensation would not be tolerated for an instant. To permit a franchise to be taken without consideration, indirectly by means of rate regulations, is obnoxious to the Federal constitution." (525)

"The fact that the franchises are to be taken in no respect impairs their value for the purposes of appraisal." (569)

**§517 Factors Determining Franchise Value.** — These are as follows:

1. Class of franchise with regard to life period and exclusive features as discussed in §238.
2. Contractual relation established by grant, as discussed in §239.
3. Cost.
4. Earning power. See §518.

**§518 Earning Power and Franchise Value.**—"The value of the franchise depends on its net earning power, present and prospective, developed and capable of development at reasonable rates. The value to be assessed is the value to the seller, and not to the buyer." (568)

**§519 Franchise Valuation for Rate Cases.**—"The fair valuation of franchises for rate making purposes cannot be earning value. Earnings are dependent upon the rates that are exacted, and hence, the higher the rates the more valuable are the franchises and vice versa. The only value that is just to both investor and consumer is that value which is represented by costs." (693, 719)

**§520 What Is Good Will?**—"Good will is nothing more than the probability that the old customers will resort to the old place."

**§521 When Good Will Is of No Value.**—"Where the Utility is practically exclusive, there can be no choice; hence the element of good will should not be considered." (568)

"Good will is of little or no commercial value when the business is a natural monopoly with which the customer must deal, whether he will or no." (492, 502)

"There is no ground upon which 'good will' can be predicated where the Utility enjoys a monopoly, and where no competition exists." (691)

"A monopoly has no good will, for its customers are retained by compulsion, not by their choice." (610)

"When the public is confined to a single Utility for the service the latter undertakes, it would seem that there is no ground upon which good will can be predicated." (691)

**§522 Where Good Will May Be Considered.**—"There may be an element of good will in the business of a Utility where competition exists and the public may resort to more than one Utility for the desired service." (691)

"Good will is a property right, having a value for the purpose of capitalization, but from its very nature, as well as from its legal doctrines, it is clear that it applies to competitive enterprises only." (693)

**§523 Good Will Cannot Be Considered In Rate Cases.**—Even under competitive conditions, good will cannot be considered in the valuation for rate regulation. (497, 702)

**§524 Criterion for Stream-Diversion Damages.**—"When water is diverted from a stream, the value of the damages is not the value of the part taken per se, but is the difference between the fair market value of the whole property and the value of what remains after the taking." (134) See §107-8-9-10.

"The value of a water power per horse power usually increases as the size of the power increases. If the power is divided, the sum of the values of the two parts taken separately will usually be less

than the value of the entire plant as a unit. The value of the remainder may in some cases be substantially destroyed by taking a part." (134)

**§525 What Riparian Rights Include.**—"A man who owns land thru which a stream of water flows has a right, which is incident to his ownership of the land, not to the water as property in and of itself, but a right to have that stream of water flow as it would under natural conditions, and make such use of it while it passes thru his land as it is possible and practicable to make without interfering with a similar right that is possessed by his next neighbors below him." (221)

**§526 Cash Basis for Water Power Value.**—This is an amount of money, the interest of which at a fair rate will yield an annual amount equal to that specified in §527.

**§527 Present Value of Water Power.**—The present value of a water power is determined solely by its earning power. It naturally has no fixed market rate and never can have. Each power privilege must be treated separately and on its own merits. (115)

**§528 Water Power Rights Must Be Valued Alone** (116, 134).—The cost of power is a separate element of all productive industries, that may be computed within close limits. In valuing a water power used to drive a mill—or any manufacturing plant—it is imperative to consider the power end by itself. The mill is simply in the position of a power consumer, the value of which is limited by the doctrines in §107-8-9-10.

The fact that the mill owner happens to be also a water power owner does not change the relation of the power consumer to the power producer, namely, that of buyer and seller. For a correct understanding of this problem it is absolutely necessary to separate the two parties, a fact which is seldom appreciated.

**§529 Valuation By Capitalization of Earnings** (267).—In this the net income of the Utility is simply capitalized at a definite rate of return per annum. The two fundamental questions are:

1. What is the income to be capitalized?
2. How is the rate of capitalization to be determined?

**§530 Net Annual Income to Be Capitalized** (267).—This is found by subtracting the sum of the following from the gross annual income:

I. Fixed charge items 1, 2, 3 and 4, defined in §558.

II. Variable charge items 1 and 2 defined in §558.

The difference between the sum of I and II just given and the gross annual income will be the net annual income available for interest and profits, and therefore the amount to be capitalized.

**§531 Methods for Determining Capitalization Rates** (267).—There are two methods for doing this:

1. Arbitrary fixing of rate by appraisers. This reflects the personal judgment of the appraising officers.

2. Basing rate on thoro study of current market records of Utility securities. This is entirely free from personal judgment, and reflects the business judgment of the entire investing public.

**§532 Requirements of Capitalization Rate Determination.**—"The determination of the proper rate to be used in capitalizing net earnings for the purpose of ascertaining the value of a specific property is a delicate task, for the reason that a slight variation in the rate may cause variations of millions in value. The rate must be worked out with the same degree of accuracy and minuteness as is desired in the result. A variation of one in the second significant place in the rate of capitalization causes a corresponding variation in the resulting value; and, roughly speaking, it may be said that the rate of capitalization must be determined to as many significant figures as are desired in the value or present worth to be found." (267)

**§533 How Rates for Utility Securities Are Determined.**—"The permanent investor is the man from whom the capital ultimately comes and, in the last analysis, the rate of return which he is willing to accept controls and determines the price of securities. An inquiry regarding the rates of return on Utility properties can therefore have no other proper basis than the market prices which the owners of capital are willing to give and to receive when they buy and sell their interests in such properties; and these prices, while they may be modified temporarily by the artificial influences and devices of the speculator, in the long run rest on the matured judgment of the investor. With the view of arriving at a price which shall fairly represent the value of the property, the course of the movement of prices must be examined over a sufficiently long period of time to warrant the assumption that the fluctuations caused by the manipulations of trader and speculator are neutralized. How long such a period should be must be determined by practical judgment in each case." (267)

**§534 Capitalization Rate Based on Value of Securities** (267).—Having determined the price which, under all the circumstances, seems fairly to represent the value of the securities, the corresponding rate of annual return to the investor may be easily determined

from any set of standard stock and bond value tables. Thus, if the average price of a 6% stock is 120, its net annual return is 5%. With bonds it is necessary also to consider their maturity in computing their net annual return. Thus a

| | | | | | |
|---|---|---|---|---|---|
| 6% | 40 | year | bond | must sell at | 117.23 to net 5% |
| " | 30 | " | " | 115.45 | " |
| " | 20 | " | " | 112.55 | " |
| " | 10 | " | " | 107.79 | " |

The average net annual return from the tables will then be the capitalization rate to be used on the net income defined in §530 for determining the valuation.

Justice is the constant wish to render every one his due.

# Chapter 12

## GOING VALUE AND GOING CONCERN VALUE

**§535 Factors Pertaining to Going Value.**—A condition precedent to an accurate, concise and comprehensive appreciation of going value is a clear conception of Utility operating conditions. These are:

1. A large fixed cash investment must be made at the start before there is any business to go on.

2. The plant cannot be moved to another locality.

3. The Utility service is limited to the possible patrons adjacent to the plant.

4. On account of the peculiar nature of Utility service and the public obligations pertaining thereto, the investment must be considerably larger than the business available in the early years would warrant in ordinary enterprises.

5. The hazard resulting from the inevitable requirement of building a plant much larger than needed at the start is important. This exposes the property to a serious loss of interest upon legitimate investment, and makes it more difficult to finance.

6. In the water, electric, gas, heating and telephone Utilities each new consumer necessitates an additional investment.

7. Depreciation of physical and intangible investment begins with the starting of the plant.

8. Plant will be made up of short life elements which must periodically be replaced.

9. To prevent impairment of investment, the plant must be adequately maintained from the beginning of operation.

10. No Utility can be a paying concern until it has obtained a paying business. To secure enough consumers, so that the income will be equal to the annual accrued liability, requires several years. Hence the operating revenues for several years will not be large enough to meet the accrued liabilities. (694)

11. The annual costs of building up the business must be carried by the owners.

**§536 What Is Going Value?** (135, 691).—The term is unfortunate in that "development cost" would have expressed the idea more definitely. It is for this reason that "going value" and "going concern

value" are so frequently confused. See §540. Going value is simply a logical and inevitable sequel to "interest during construction" and can readily be calculated for any Utility. It is not a permanent deficit, but a temporary one only, because the investment has not had time to bring an adequate return.

Going value may be defined as the cost to the owner to bring the plant to a self-supporting basis; hence it is based on the losses of the earlier years of operation, and is the uncompensated cost incurred in building up the business.

**§537 Mere Physical Plant Amounts to but Little.**—"A mere physical plant, no matter how perfect or how well it is adapted to the purpose for which it is intended, amounts to but little unless it has or can obtain a paying business. Without business it is a dead mass instead of a living concern earning profits. To have profits it must have business or customers who avail themselves of the services it renders at rates that yield an adequate income." (693)

**§538 Going Value Is Inevitable.**—"The cost of building up the business of a plant is in most cases as unavoidable as the cost of the construction of the plant itself." (697)

**§539 What Going Value Includes.**—"The cost of developing a Utility business may be made up of many different kinds of expenditures. It may include the cost of advertising, of soliciting, of demonstrations showing the advantage of the service, of making free connections, of the granting of lower than the regular rates, and of many other outlays of this character in order to secure customers. It may also include losses to the investors because of the fact that the plants in their earlier years failed to earn enough to meet all the requirements for operating expenses, including depreciation and a reasonable return upon the investment." (696)

**§540 Going Value Distinguished.**—Going Value is a distinct species of intangible value and is entirely separate and distinct from going concern value, franchise value or good will.

**§541 Established Business Enhances Value.**—"An established Utility may be worth more than its original cost and more than the mere cost of its physical reproduction. It has passed the initial period of little or no return to its owners which of greater or less duration almost always follows construction. The inevitable errors in its building which finite minds and hands cannot avoid have been measurably corrected, time and effort have produced a commercial adjustment between it and the country it was intended to serve, relations have been established with patrons, and sources of traffic have been

opened up and made tributary. In other words, the Utility, unlike one newly constructed, is fully equipped, and is doing business as a going concern." (539)

**§542 Service Connection Cost No Criterion of Going Value.**—A popular fallacy is that "going value is the cost of getting the plant connected with the customer. Obviously, this does not bear investigation for many reasons, for while the consumer is being connected, the works are being operated at a loss; interest charges are not being met; depreciation is beginning and is not recoverable. In many other ways going value costs are incurred which would not appear in the computation. It is certain that mere cost of the house service has little if anything to do with going value." (135)

**§543 Physical Property Cost No Criterion of Going Value.**—The attempt to estimate going value from physical property cost is a mere guess, and of no value. (135)

**§544 Relation of Going Value to Earnings.**—"While going value has no existence without earnings, it is not necessary that the earnings shall equal expenses to give it a status. In other words, a plant may be losing money and still have a going value." (691)

**§545 Going Value May Exist Without Franchise.**—"Going value is always to be considered an element for valuation. It is independent of the franchise value and may exist when the franchise has expired." (691)

"Altho the franchise has expired, the plant is to be taken over as a going concern, and just compensation must be awarded for the property taken as a living and operating entity, engaged in serving the public, and not a mere plant without patrons." (691)

**§546 Justice of Going Value.**—"Investigations of the facts involved make it quite obvious that justice between the investors on the one hand, and the consumers on the other, requires that in valuing Utilities consideration should be given to the amounts expended by the former in building up the business of such plants." (710)

**§547 Going Value Rights of Investors.**—"When losses are due to delays in securing the required amount of business, which cannot be reasonably avoided and have not been covered by subsequent surplus earnings, it is difficult to escape the conclusion that they must also be regarded as one of the elements that should be considered in appraising the plants and fixing their rates. If investors are not compensated for such losses, either by being allowed reasonable returns thereon or through surplus earnings, they will not continue to invest their money in plants of this kind. Again, the investors would

seem to be entitled to such compensation on the ground of equity alone; for these losses enter into the cost of the service and, under normal conditions, it is only fair that the rates charged for the services rendered are fixed at a level that is high enough to cover all reasonable costs." (710)

**§548 Going Value Must Be Considered in Fixing Rates.**—"Every effort honestly put forth, every dollar properly expended, and every obligation legitimately incurred in the establishment of an efficient Utility business must be taken into consideration in the making of rates for such business. Collectively the elements just referred to may be designated by the term "going value" and in this sense there can be no question regarding the propriety and justice of admitting going value as a consideration in the determination of rates." (697)

"The rate of return to be allowed upon the investment should be such as to offset the losses in early years." (683)

**§549 Liquidation of Development Expense or Going Value.**—The development "deficits may be covered either by being regarded as a part of the investment and included in the capital upon which interest is allowed, or they may be carried until they can be written off when the earnings have so grown as to leave a surplus above a reasonable return of the investment that is large enough to permit it. When capitalized, they become a permanent charge on consumers. When charged off from surplus, they are gradually extinguished. These facts alone, however, do not always furnish the best or most equitable basis for the disposal of such deficits. Whether they should go into the capital account, or whether they should be written off, as indicated, are questions that largely depend on circumstances in each particular case." (695)

**§550 Going Value May Be Capitalized.**—"During the time of development, there is a loss of money actually expended and of dividends upon the property invested. How shall this be taken care of? Must it be borne by the owner of the plant, or by the initial customers? Or shall it be treated as part of the investment or value of the plant, constituting the basis upon which charges shall be made to all customers who receive the benefits from the increased service-rendering power of the plant by reason of these expenditures? The last solution is the logical, just and correct one." (602)

**§551 Judicial Recognition of Going Value.**—"The element of 'going value,' created by the investments made in developing the business and in addition to the cost of the physical structure, must be taken into consideration in fixing value." (691)

"The courts have almost universally held that this element is an important and valuable consideration, which cannot be left out of account in fixing the fair value of the property of a Utility. Slight consideration is necessary to see that the final deduction is based upon sound premises, because an investigation into the financial history of any Utility will disclose that investments have been made, in addition to the cost of the physical structures, in order to keep the business going and to develop the same to a point where the revenue derived from the business was sufficient to meet operating expenses, cost of maintenance and depreciation, and provide some return upon the investment." (691)

**§552 Cost of Developing Business.**—A typical case is illustrated in Fig. 40, p. 182, which is based on the following data:

1. Original investment of $100,000, made up of $50,000 5% 40 year bonds sold at 90, and $50,000 7% stock sold at par.

2. Intangible property investment, $30,000.

3. Physical property investment, $60,000.

4. Working capital, $10,000.

5. Original physical property investment increased $\frac{1}{30}$—or $2,000—each year for plant extensions.

6. Original investment to be retired in 40 years.

7. The physical property contains short life elements which must be renewed several times in a manner similar to the data given in Fig. 31, p. 127. The values of the respective life elements are 60% of those given in Col. B of Fig. 31, p. 127.

8. The sinking fund for maintaining the integrity of the investment to bear 3% annual interest, compounded annually.

9. Annual running cost indicated by A B.

10. Annual tax cost indicated by B C.

11. Annual insurance indicated by C D

12. Annual executive cost indicated by D E.

13. From data 6 and 7 and Col. F of Fig. 31, p. 127, the annual payments to maintain the integrity of the original $60,000 physical investment will be 60% of $5,276, or $3,165.60. To comply with datum 5, this is increased $\frac{1}{30}$ each year. It is indicated by E F on Fig. 40, p. 182.

14. Five per cent of $50,000, or $2,500, will be the annual interest on bonds. This is indicated by F G.

15. From 3% Col. of Table 5, p. 242, the per cent of the intangible investment that must be set aside each year to comply with datum 6 is 1.33%. Hence amount equals 1.33% of $30,000, or $399. This is indicated by G H.

16. The annual maintenance allowance is indicated by H I.

17. The 7% annual interest on the $50,000 of stock amounts to 7% of $50,000, or $3,500. In accordance with datum 5 this must be increased by 7% of $2,000, or $140 each year. It is indicated by I J.

18. Total annual accrued liabilities indicated by A J.

19. Gross income revenue indicated by curve K K.

**§553 Calculation of Going Value.**—This is graphically shown in Fig. 40, p. 182.

**§554 Going Value in Municipal Utilities.**—Most municipal plants attempt to avoid this by:

1. Making the maturity of bonds beyond the normal life of the plant, thus decreasing the pro-rated annual burden.

2. Refund bonds at maturity, thus placing a burden on a future generation.

3. Raise the interest and sinking fund from general taxation instead from plant revenue, as a private concern must do.

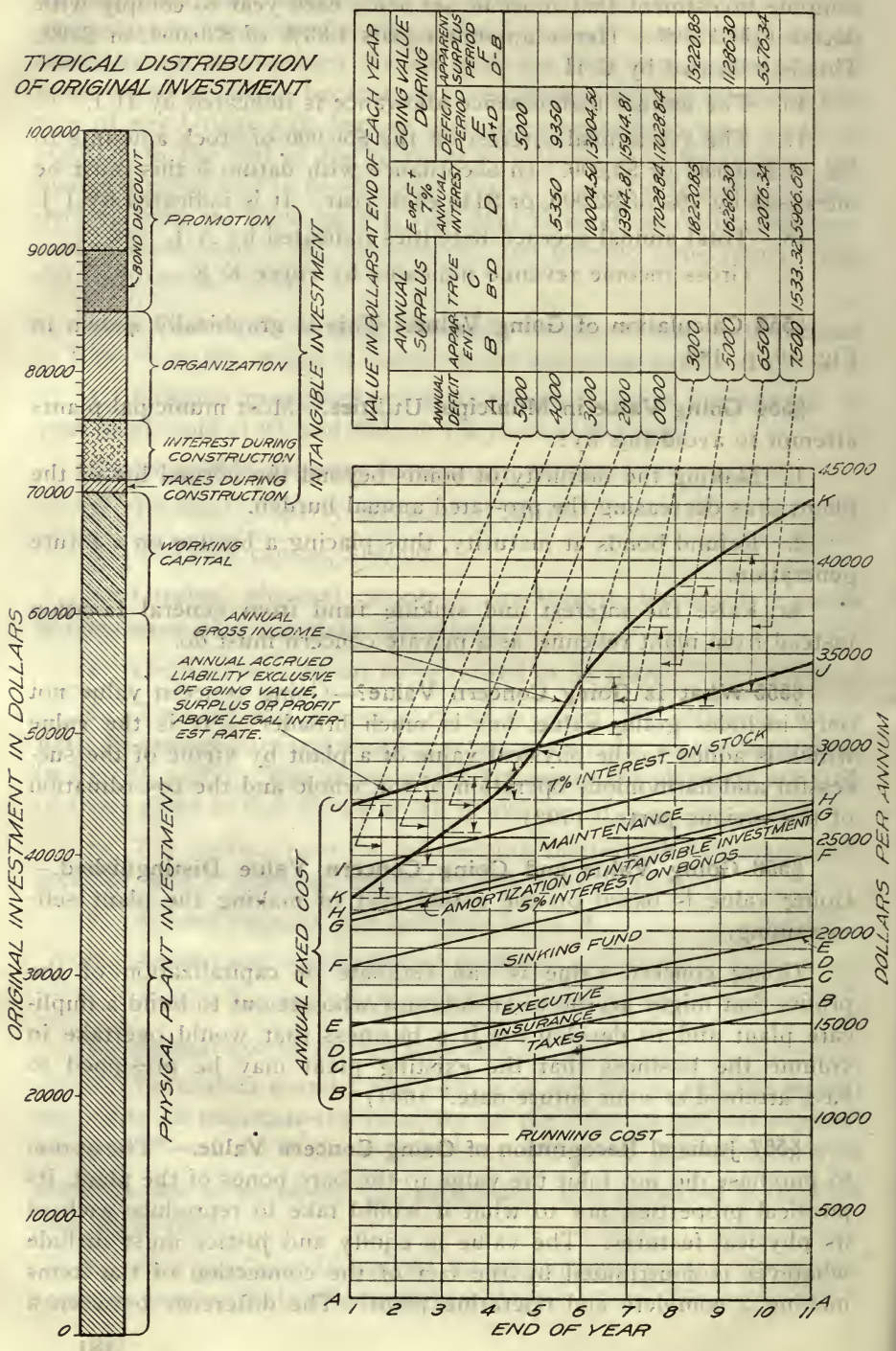
**§555 What Is Going Concern Value?**—Going concern value not only includes going value, but is much broader. "It is the value which is added to the physical value of a plant by virtue of the successful and harmonious operation of the whole and the co-ordination of the various parts." (702)

**§556 Going Value and Going Concern Value Distinguished.**—Going value is based on the actual cost of making the plant self-sustaining.

Going concern value is "an estimate or capitalization of the profits that might accrue to an investor who set out to build a duplicate plant and to develop for it a business that would overtake in volume the business that the existing plant may be presumed to have attained at some future date." (684)

**§557 Judicial Recognition of Going Concern Value.**—"The option to purchase did not limit the value to the bare bones of the plant, its physical properties, nor to what it would take to reproduce each of its physical features. The value in equity and justice must include whatever is contributed by the fact of the connection of the items making a complete and operating plant. The difference between a

# FIG. 40
# CALCULATION OF GOING VALUE OF UTILITY PLANT



dead plant and a live one is a real value, and is independent of any franchise to go on, or any mere good will as between such a plant and its customers." (502)

"In estimating the sum to be paid, the commission was not confined to a valuation of the bare physical plant, and committed no error in taking into account its earning capacity as a going concern." (564)

"The allowance above the cost of duplication less depreciation, because the corporation was sold as a going concern, was justified." (572)

"In determining the amount to be added to structure-value, in consideration of the fact that the system is a going concern, the appraisers should consider, among other things, the present efficiency of the system, the length of time necessary to construct the same de novo, the time and cost needed after construction to develop such new system to the level of the present one in respect to business and income, and the added net incomes and profits, if any, which, by its acquirement as such going concern, would accrue to a purchaser during the time required for such new construction, and for such development of business and income." (568)

"The fact that a system is in operation—not only with a capacity to earn, but actually earning—makes it true that the fair and equitable value is in excess of the cost of reproduction." (512)

"In placing a value on the physical property of a plant, the units of a plant should not be valued as independent entities, but as units of a going concern performing public utility service." (691)

"A system of water works in a city, without the right to operate there, or without being connected with water takers, and not in a running condition, would be comparatively worthless. The water company was the owner of these important elements of value, and it seems reasonable that they should not be taken without compensation." (565)

Cost embodies three distinct elements: First, actual expenditures in production. Second, provision to keep investment intact. Third, rate of return on investment commensurate with the hazard in the enterprise.

# Chapter 13

## PRINCIPLES GOVERNING COST OF UTILITY SERVICES

**§558 What an Adequate and Equitable Rate Schedule Must Provide For.—**

I. Recognition of economic features discussed in Chapter 3.

II. Fixed charges to:

1. Keep investment intact by providing:

A. That bonds will not have a longer life than the property that they cover.

B. Annual sinking fund large enough so that, by the time that parts of plant which were paid for by bonds become useless, the bonds will be retired.

C. Annual contribution to reserve fund to cover the functional depreciation discussed in §320.

D. Annual maintenance for property, see §326.

E. Annual contribution to reserve fund to cover all the species of contingent depreciation shown in Fig. 20, p. 103.

F. Annual amortization of intangible property investment, as defined in §349.

G. Annual sinking fund to maintain integrity of investment not covered by items B and F.

H. In the case of natural gas plants, all the investment —intangible and physical—dependent on the life of the gas field must be returned during the period of the useful commercial life of the field.

2. Pay all fixed taxes against property, corporation or franchises.

3. Insure property against damage from elements.

4. Pay all executive expenses.

5. Pay interest on securities, based on true valuation of physical and intangible property.

III. Variable charges, consisting of:
   1. Running costs.
   2. Liability assumed by Utility with contract to render service.
   3. Profit commensurate with hazard involved and risk assumed by Utility in rendering service.

IV. Meters for measuring service must be furnished by Utility.

V. Each consumer must pay for service he receives.

VI. In the case of an electric street railway, the cost of an adequate return circuit and the protection of adjacent underground structures from stray electric currents must be borne by the railway and figured in the cost of the street car service.

**§559 False Basis for Valuation for Rate Making.**—The fallacious claim is sometimes made that merely the cost of reproduction less accrued depreciation or, where a sinking fund is maintained, the reproduction cost less the accrued value of the sinking fund, ought to be the valuation basis for rate making. The error, falsity and absurdity of this claim will be evident from the following:

1. The original investment is not and cannot be reduced until there is a specific repayment or replacement of a part of it out of the income from the property. If such a replacement is made, it is not a distribution of earned profits, but merely a return of original capital.
2. A normal sinking fund to provide for the inevitable depreciation does not represent profits, but an expense without which profits can never be ascertained.
3. The sinking fund simply ultimately repays or retires the original investment intact; it does not and cannot pay profit on the investment.
4. Interest and profit on total investment are not only separate and distinct from the sinking fund, but are in addition thereto.
5. The sinking fund becomes available only at the end of the life of the investment that it protects.

**§560 Correct Valuation Basis for Rate Making.**—"The valuation of a Utility and its earnings must bear such relation to each other that there will be returned to the owner, within the life of the property, the capital which he has properly invested in it and, in addition thereto, interest at a reasonable rate upon such amount of capital as from time to time actually and properly remains in the property as an investment." (111)

**§561 Relation of Rate Determination and Valuation.**—These are interdependent. We cannot fix a schedule of equitable rates without knowing the true value of the property, and one cannot value without rating.

**§562 Factors Entering into Cost of Utility Service.**—The outlines for two typical Utilities are given in Figs. 41, p. 187, and 42, p. 188.

**§563 Public Duty Linked With Fair Rates.**—The Utility is not engaged in a private business for profit, limited only by competition and the laws of supply and demand, but in the performance of a public duty, subject to the requirements of efficient service and fair rates.

**§564 Distinction Between Rate Regulation and Rate Making.**—Rate regulation is confined to rates in the aggregate. Rate making is the adjustment of individual rates.

**§565 Fallacy of Comparative Statistics.**—Fair rates cannot be determined by comparison of rates in other communities, since identical conditions probably never exist, and weight cannot be given readily or intelligently to the different causes which might affect them. For instance:

"Some towns are so situated as to make the procurement of an ample supply of water comparatively inexpensive. Some are so situated as to make the work both difficult and expensive. What would be an extortionate charge in the first case might be the very least at which water could be afforded in the other." (608)

"Rates maintained in one section of the country are not a safe standard by which to measure the reasonableness of rates in another section where the expense of operation and other conditions are substantially different." (640)

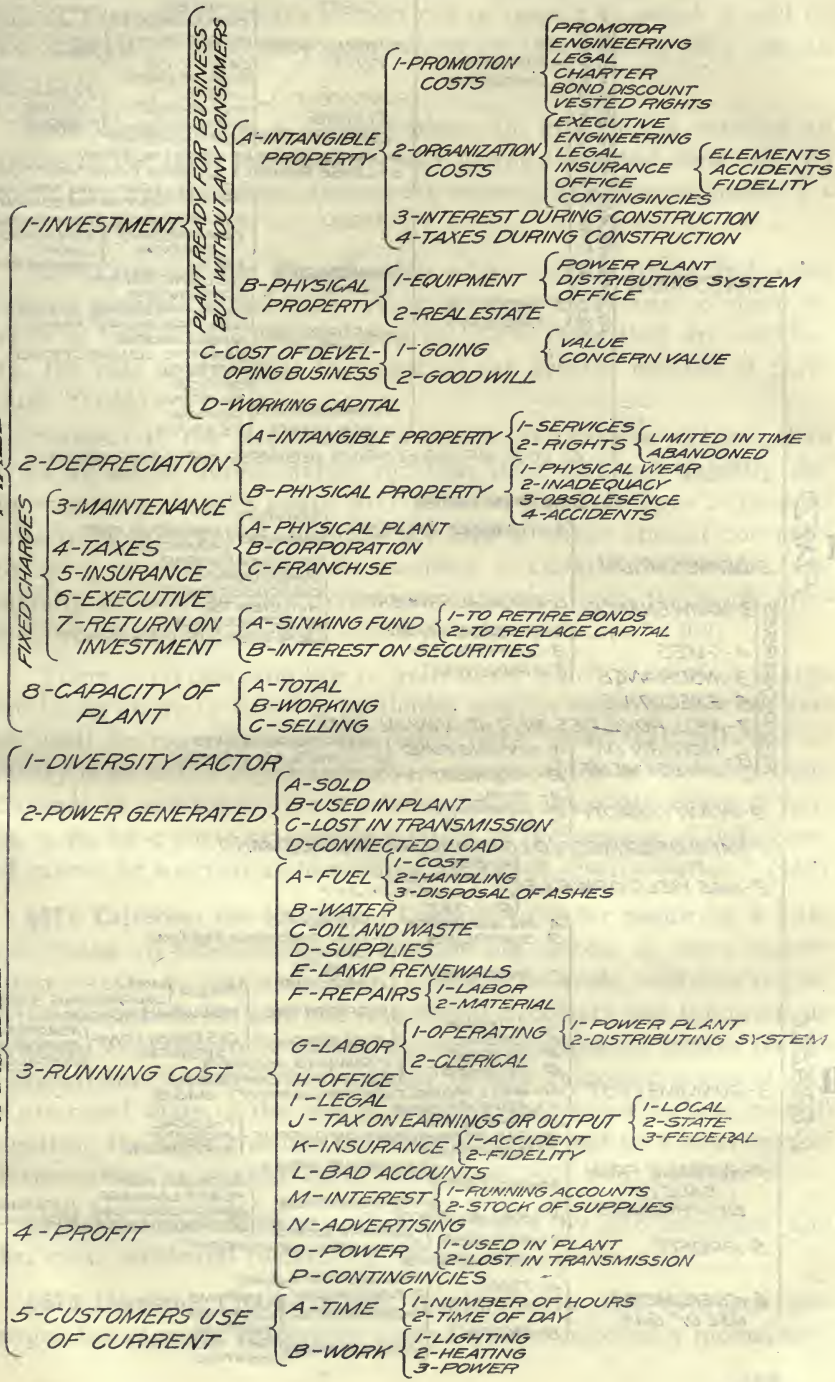
**§566 Nature of Utility Service Determines Cost.**—The cost and value of Utility service varies with the nature or amount of the service rendered. In any equitable rate system each consumer must—as nearly as possible—pay for the particular service that he receives. As the service demands of different consumers are unlike, it is evident that equity to all is not necessarily equality to all.

"Where there is dissimilarity in the services rendered by a Utility to different persons, a difference in charges is proper." (456)

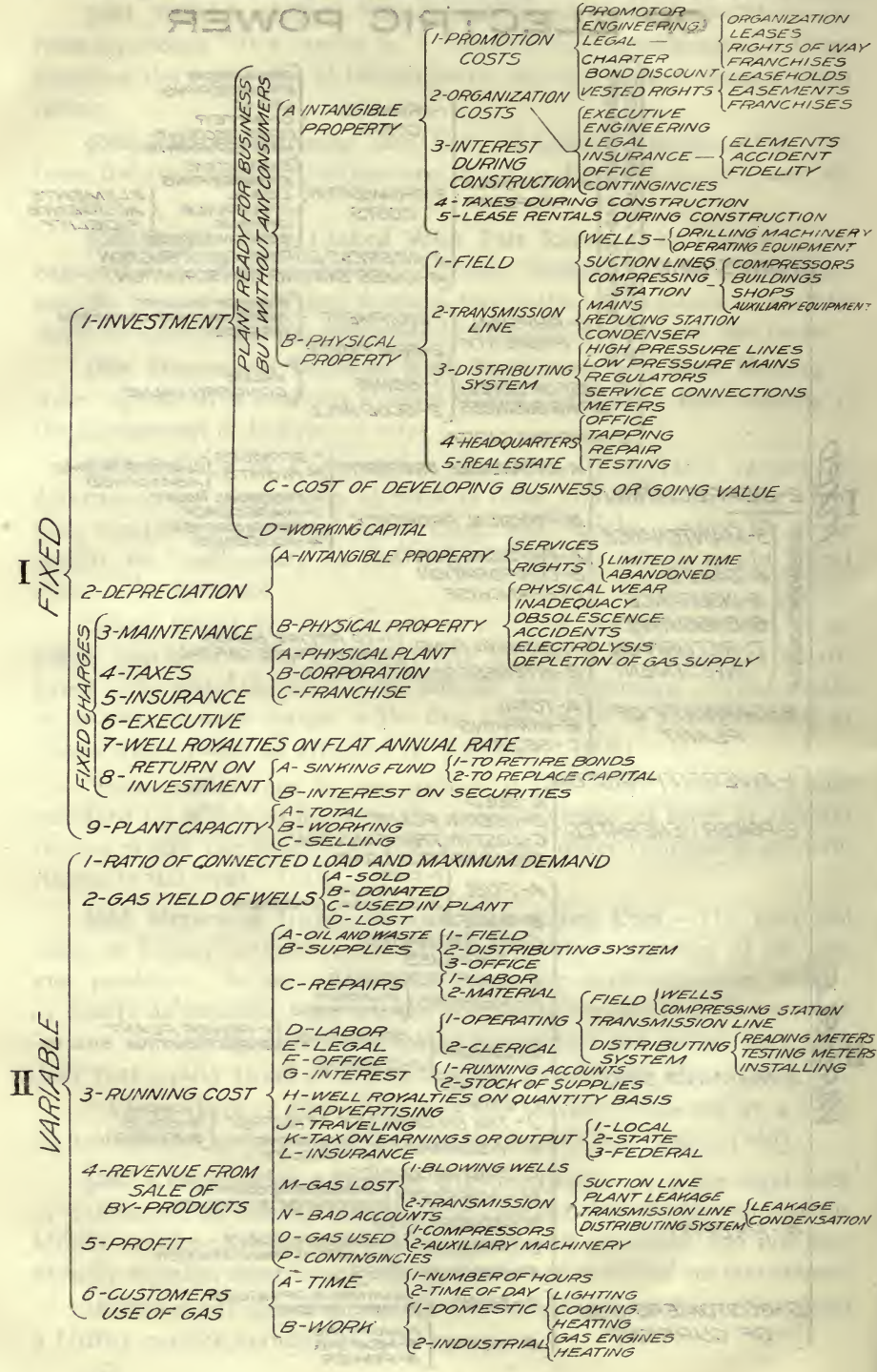
**§567 Classification a Duty of Utilities (649).**—It is the legal duty of Utilities so to classify and fix their charges that the burdens of the Utility service shall be reasonably, justly and equitably, but not necessarily equally, distributed over the services rendered its consumers.

However, all classification must be based upon a distinction from a Utility service standpoint. (657)

# FIG. 41
# FACTORS DETERMINING COST OF ELECTRIC POWER



# FIG. 42
# FACTORS DETERMINING COST OF NATURAL GAS



**§568 Classification of Services in General.**—An exact classification is impossible. Unless the number of classes is indefinitely increased, there must always be services in respect to which it will be very difficult to determine into which of two classes they should fall. (644)

**§569 Classification a Compromise.**—In grouping a number of services in the same class and thereby giving them the same rate, no two will be exactly alike. In its very nature, classification must be a compromise. (637)

**§570 Criterion for Classification.**—"As classifications and rates must be general, an injurious effect in some cases and to some interests is unavoidable; but as long as in the main they are satisfactory, the rule applies that the good of the greater number is paramount." (633)

"Subject to the two leading prohibitions that the charges shall not be unjust or unreasonable, and that they shall not **unjustly** discriminate so as to give undue preference or disadvantages to persons similarly circumstanced, Utilities are free to make special contracts looking to the increase of their business, to classify their traffic, and generally to manage their important interests upon the same principles which are regarded as sound in other pursuits." (409)

"There is no cast-iron line of uniformity which prevents a charge from being above or below a particular sum, or requires that the service shall be exactly along the same lines. But that principle of equality does forbid any difference in charge which is not based upon difference in service, and, even when based upon difference of service, must have some reasonable relation to the amount of difference, and cannot be so great as to produce an unjust discrimination." (455)

**§571 Criterion for Extension Costs.**—An order requiring a Utility to make an extension to its distributing system to serve remote customers, "to be just and effective should be made with due regard for the magnitude for both the investment necessary and the probable additional earnings to be gained thereby, including the return on the additional investment." (734) If the remote customer does not pay his pro-rated share of the cost of bringing the service to him, he will be getting the service at less than cost and this will be a clear case of discrimination as against other consumers.

**§572 Customer Charge.**—This is caused by the expenses and other costs incidental to carrying an account.

**§573 Demand Charge.**—This originates in the expenses and charges for capacity equipment caused by the maximum momentary

demand of each individual customer in relation to the maximum momentary aggregate demand of all customers.

**§574 Consumption Charge.**—This is the basic cost at which Utility service can be sold under given local conditions when it is freed from the customer and demand charges defined in the two preceding sections.

**§575 Unprofitable Rates Are Discriminating.**—"To put into effect for permanent use a rate schedule which is so low as hardly to cover the output costs, or that yields so little in the way of revenues as to leave little or nothing for interest, depreciation and taxes, would seem to be out of line with sound business practice, and discriminating as against other customers." (701)

"The community is benefitted when the Utility acquires all the load to which it is economically entitled, on a fair basis of cost in each case. But when the load is obtained by offering rates at less than cost, to meet private competition, the resulting benefits to the Utility and the consumer in question come out of other consumers; there is then no economic benefit to the community and in addition there is unfair discrimination as between consumer and consumer." (177)

"A system of charging which permits any business to be carried at less than the cost to the company and permits the acquisition of business which might be had on a profitable basis, means that the community pays more on the whole for service than would be required under a rational system of charging." (204)

**§576 Unpaid Service and Service Cost.**—"It is self-evident that no person can be served by a Utility without compensation, without compelling others to pay the cost of such service." (706, 727)

It is to the interest of every honest consumer to have all Utility service paid for. Every "dead beat" or "dead head" patron is a social parasite that subsists on those who pay their bills. Every unpaid bill or free service represents a loss that inevitably tends to increase the cost of service to the honest consumers, and is a factor that must be reckoned with in service-cost determinations.

**§577 Right and Duty of Utility Is to Minimize Losses.**—"In order to discharge properly its obligations to its patrons, it is manifestly essential that the Utility receive promptly, at stated periods, all indebtedness due for service rendered, and that no losses be incurred by reason of uncollected accounts of either the dishonest or the impecunious patron." (106)

"The Utility has the right to adopt a rule which, while giving the honest citizen what he pays for, will prevent the dishonest from getting what he never paid for, and never intended to pay for." (613)

The legal methods for realizing this are given in §578-79-80-81-82-83.

**§578 Security for Credit.**—Adequate security may be required of any Utility patron to insure the prompt payment of bills for service rendered, for "the company should not be compelled to furnish service without reasonable security for payment." (619, 706)

**§579 Cash Deposit.**—"The Utility may require of any patron the deposit of a reasonable sum of money as security for the prompt payment of bills when due." (706)

**§580 Amount of Cash Deposit.**—"In determining the reasonableness of the amount to be deposited, the probable amount of the indebtedness that may be incurred during the stated period at the end of which bills are made out and rendered, is an important factor. No more than a sum sufficient to furnish adequate security for the credit extended may be legally exacted." (573, 706)

**§581 Advance Payment.**—"That the Utility may establish a rule exacting payment in advance in reasonable amounts is fully settled." (587, 706)

**§582 Penalize Delinquent Patrons.**—"The Utility may allow a discount upon bills paid on or before a stated day, or exact a penalty for failure to make payment within a certain time." (618, 706)

**§583 Utility May Shut Off Service.**—"For neglect or refusal on the part of any patron to comply with any of the legal rules and regulations, the Utility may discontinue service to such patron." (618, 706)

**§584 Non-Discriminating Rates.**—The true non-discriminating system of rates is one in which the charge to the consumer bears a definite proportion to the cost of supplying him.

"The rates for services rendered by Utilities should, very largely, be based upon the cost to the plants of furnishing these services." (699)

"It is of the greatest importance that the rates be so adjusted that each consumer is made to bear his just proportion of the total cost." (720)

"Rate schedules should follow the cost curve as closely as possible." (722)

"Rates, to be equitable and just, should be based upon the cost of rendering the service." (726)

**§585 Relation of Policy to Rate Reductions.**—"The question of policy must also be considered. It is a good policy for a Utility to refrain from such a differentiation of rates as will result in any class of business being transacted without profit. Policy forbids the reduction of rates to such a point as causes unfavorable comment. The Utility must to a greater or less degree be governed by public sentiment." (43)

**§586 Status of the Large Customer.**—"The large customer is a desirable one, and there is a constant temptation to discriminate in his favor. A Utility, however, has no right to so discriminate. It may make a difference in its rates to him, but only within definite limits and by a consistent rule. The Utility has a right to let him participate in the economies which result from his favorable conditions, but the difference in the rate made for this cause must not be disproportionate thereto." (43)

**§587 Reductions in Rates Based on Mere Quantity Are Wrong.**—"Discriminations in price based solely on the amount consumed by different customers are never justifiable." (675)

"A rate schedule which offers opportunities for lower charges for greater than for smaller amounts of service, under conditions that are similar in other respects, is objectionable." (721)

"A schedule of rates which allows reduced rates for quantities consumed, without reference to the size of installation, the demand, or the hours of use, is not likely to be in keeping with the costs of service or conducive to the successful extension of business." (700)

**§588 Sliding Scale Based on Mere Quantity Is Inequitable.**—"As a general proposition, the claim of the petitioner that a sliding scale, such as that in force by respondent, is unjust and inequitable, is borne out by the facts. A rate schedule which recognizes only the quantity consumed and neglects the factors of active connected load and hours daily use of the connected load, must necessarily fail to distribute the costs equiltably." (721)

**§589 Discount Based on Mere Quantity Is Inequitable.**—"A rate schedule which has a discount scheme under which it is possible for one customer to receive service at a lower rate per unit than another consumer of the same class, and with the same connected load, is inequitable." (718)

"A Utility cannot support a discount based on quantity of service rendered to one consumer, on the principles which are applied among merchants, whereby they give better prices in wholesale than

in retail dealings. The cases are not analogous, since the naming of the quantity of services that shall be compared to wholesale purchases must necessarily be altogether arbitrary, and the duty of impartial service which the Utility owes to the public will preclude special discrimination being made by arbitrary tests." (625)

**§590 Distinction Between Meter Rental and Minimum Charge.**—A meter rental is rental for equipment which the Utility is under obligation to furnish the consumer, and the rental is added to the bill regardless of the monthly service consumption. It is wrong in principle and cannot legally be enforced; see §597.

The minimum charge, however, is a monthly charge for service rendered by the Utility and received by the consumer, regardless and independent of the service consumption. It is not made in addition to the consumption charge, but merely fixes the minimum monthly return per consumer and in this way prevents discrimination between consumers, by making each pay for his pro-rated share of the fixed charges which always go on regardless of service consumption. As soon as the price of the month's service units used becomes equal to or greater than the minimum charge, the consumer is simply charged for the number of service units actually used, because the minimum charge is never added to the service consumption. It should always be used to insure justice to all consumers. See §591-2-3.

**§591 Object of Minimum Charge.**—"The chief argument for the minimum charge is that it covers expenses that in the ordinary rate schedules cannot be covered in any other way." (717)

"Minimum rates are intended to cover the fixed expenses for those who use so little service that the cost of carrying them would not otherwise be met." (704)

**§592 Minimum Charge Necessary and Just.**—"Under meter rates, revenue is available only when service is used, and it is a common experience that many customers do not use sufficient service to incur a bill large enough to meet fixed expenses alone. A minimum bill therefore is both necessary and just." (715, 125)

**§593 Absence of Minimum Charge Produces Discrimination.**—"Where no minimum charge is made, the Utility is compelled to carry considerable dead investment and incur other expenses for those consumers who pay very little to the Utility, and when such costs are not borne by the consumers for whom they are incurred, they usually have to be carried by other consumers, and are therefore in a sense discriminatory." (717)

**§594 Legal Right of Minimum Charge.**—"We do not think it can be reasonably contended that it is not competent to charge a minimum rate. We think it clear from the authorities that the company had a right to fix a fair and reasonable minimum charge for water supplied to any particular residence." (617)

"The defendant then, apart from the contract, had a right to fix a fair and reasonable minimum charge to compensate it for necessary expense and service in inspecting meter, and for service used in a quantity not provided for by the contract." (580)

"An ordinance, enacted by a city furnishing natural gas to its inhabitants, is not presumptively unreasonable because it requires a minimum charge of 50 cents a month, regardless of the amount of gas used." (605)

"It is a matter of common knowledge that to furnish service for the very small consumer requires the same outlay, in the way of a meter, service connections, repairs, and periodical visitation, that is required for very large consumers." (579)

"The constant condition of readiness to serve is a necessary and unavoidable obligation which must be sustained, in order to meet instantaneously the demand for service which the consumer is entitled to have at any moment that he wishes it. It thus forms a part of the service to be rendered and is an item properly to be considered when the reasonableness of the charges exacted by the Utility is called in question." (593)

**§595 Minimum Charge Is Not a Penalty.**—The minimum charge is not a penalty for a failure to use service, "but is properly to be regarded as compensation for that part of the service which is at all times being rendered in the maintenance of the apparatus and connection thru which the service is made available." (594)

**§596 Monthly Basis for Minimum Charge Best.**—"The exaction of a minimum charge is a reasonable rule and the making of this charge by the month is just and reasonable, and is more equitable than if the charge were made by the year." (677)

"Following is an analysis of the costs which are in proportion to the number of customers, taken from the books of a typical electric company: (677)

| | Per Customer per annum. | Per Customer per month. |
|---|---|---|
| Meter Expense and Maintenance | $1.06 | .088 |
| Repairs to Services | .29 | .024 |
| Office Salaries and Expenses | 2.70 | .225 |
| Expense Collection | .66 | .055 |
| Indexing Meters | .27 | .023 |
| Distribution Expense (general work) | 1.08 | .090 |
| Expense 15% | .78 | .065 |
| | $6.84 | .570 |
| Interest on cost of meter and service, 6% | 1.47 | |
| Depreciation on Meter (10%) and Service (7%) | 2.07 | |
| | $10.38 | .865 |

**§597 Utility Must Furnish Meters.**—"The meter is necessary to the Utility in the measurement of its service. The consumer is required to pay the legal rate for the quantity consumed, and this quantity must be ascertained by the Utility by some correct method." (566)

"The requirement that the party furnishing service shall provide the means necessary for its measurement is not an unreasonable regulation. The expense of the meter could not be imposed on the consumer." (562)

"The logic is overwhelming to the effect that meters constitute a part of the facilities incident to the service for which the management, whether public or private, is responsible." (562)

**§598 Interstate Commerce Commission Decisions.** — The data contained in these cover practically all phases of the complex railroad rate question, and the general principles are applicable to all Utilities.

"The facts presented in this long series of cases are kaleidoscopic. Never, perhaps, does exactly the same group of facts reappear in exactly the same relationship. Tho each decision has its peculiar characteristics, an analysis and comparison of many cases reveal certain common elements or underlying principles." (60)

A co-ordination of these principles is shown in Fig. 43, p 196, and is briefly discussed in §599 to §633. For further discussion see (63) and (19).

# FIG. 43
# FACTORS ENTERING INTO FREIGHT RATE DETERMINATION

- 1-VALUE OF COMMODITY
  - CRITERIA
    - MARKET VALUE
    - ADVERTISING DESCRIPTION
  - CARRIERS LIABILITY, RELATION TO
  - NOT ONLY TEST
  - RATE MAY FLUCTUATE WITH
  - RATE MUST BEAR SOME RELATION TO
- 2-COST OF SERVICE
  - NOT SOLE CRITERION
  - CANNOT BE ACCURATELY APPORTIONED
  - EXTRA SERVICE JUSTIFIES HIGHER RATES
  - COMPARISONS NOT SAFE
  - LESS IN CAR LOAD LOTS
  - LOCAL SHIPMENTS COST MORE THAN THRU
  - MINIMUM CHARGE JUSTIFIED
- 3-RISK
- 4-DISTANCE
  - RELATION TO TERMINAL CHARGES
  - NOT ALWAYS CONTROLLING
  - COST PER MILE DOES NOT INCREASE WITH
  - RATES NOT PROPORTIONAL TO
  - INCREASE MUST BE GENERALLY CONSIDERED
  - SHORT HAUL MAY COST MORE THAN LONG
- 5-TON MILE
  - STATUS OF
  - NO TEST FOR LOCAL RATES
  - LIMITATIONS
- 6 NATURAL ADVANTAGE OF LOCATION
  - MUST BE RECOGNIZED
  - MUST NOT BE NEUTRALIZED
  - MUST NOT BE DISCRIMINATED AGAINST
- 7-COMPETITION
  - LAWFUL TO CONSIDER
  - TEST FOR
  - AS A REGULATOR OF RATES
- 8-ONE RATE CANNOT BE CONSIDERED BY ITSELF
- 9-RATE LIMITS
  - MAXIMUM
  - MINIMUM
- 10-WHAT TRAFFIC
  - WILL BEAR
    - DEFINITION OF
    - JUDICIAL RECOGNITION OF
  - WILL NOT BEAR
- 11-PROFIT
  - REASONABLE RATE INCLUDES
  - WHEN MAY BE EXCLUDED

**§599 Market Value of Commodity and Transportation Rate.**—"The value of an article to the manufacturer is the price it commands, and it seems only reasonable that carriers should take into account the market value, a thing generally known and easily ascertained, as one of the considerations in arranging their classifications and fixing the rates that a commodity should bear." (635)

**§600 Advertising Description of Commodity Determines Its Classification.**—"A manufacturer's description of an article to induce its purchase by the public also describes it for transportation and carriers may accept his description for purposes of classification and rates." (636)

**§601 Relation of Carriers' Liability to Commodity Value.**—"The element of value in the commodity transported forms a proper consideration to be taken into account in the establishment of a rate." (630)

**§602 Commodity Value Not Only Test.**—"While value is a most important element, it plainly cannot be made an arbitrary standard independent of all other considerations." (646)

**§603 When May Rate Fluctuate With Commodity Value?**—"Freight rates ordinarily should not vary with the price of the commodities which are transported." However, "a railroad company may properly make a low rate in times of business depression, for the purpose of enabling a manufacturer to continue in business. It may also restore such rate when the period of depression is passed." (655)

**§604 Rate Must Bear Some Relation to Commodity Value.**—"When the market price of a commodity yields but scant return for labor and expenses of production, the cost of transportation needs to be as moderate as may be consistent with justice to the carriers." (642)

**§605 Cost Is Not Sole Criterion.**—"While cost is an element to be taken into account in the fixing of rates, and one of the very highest importance, it cannot, for reasons well understood, be made the rate basis." (624) "The element of cost of service has long ceased to be regarded as the sole or most important factor." (626)

**§606 Costs Cannot Be Accurately Apportioned.**—"It is impossible to apportion with accuracy the cost of service among the items of the traffic. Any attempt to apportion the cost would at the best and under the most favorable circumstances reach only an approximation. This is so well understood the world over that the propo-

sition, which from time to time is made in other countries, to measure the charge of the carriers by the cost of carriage solely, has always been abandoned after investigation." (624)

**§607 Extra Service Justifies Higher Rates.** — "The Interstate Commerce Commission has reached the very reasonable conclusion that where the conditions of the traffic are such as to require some special service on the part of the carriers, involving unusual expenditures, the carriers are justified in demanding higher rates to cover these extra costs." (63)

**§608 Rate Comparisons Not Safe.**—"Rates maintained in one section of the country are not a safe standard by which to measure the reasonableness of rates in another section where the expense of operation and other conditions are substantially different." (640)

**§609 Car-Load Rates.**—"The cost of service is very considerably less in the case of shipments in car-load lots than in less than car-load quantities." (627)

**§610 Cost of Local Shipments Greater Than Thru Shipments.**—"In determining the reasonableness of freight rates, it must be recognized that the cost of handling local shipments is relatively greater than thru shipments." (532)

**§611 Minimum Charge Justified.**—"The necessary expense and trouble attending the carriage of less than car-load shipments, large or small, which, aside from the actual manual labor involved, are practically the same irrespective of the weight and bulk of the package, justifies the fixing of a minimum weight and charge for the transportation of such shipments." (653)

**§612 Risk as a Rate Element.**—"Risk is always an element to be considered in making rates. Articles which are dangerous and destructive or perishable and destructible must pay a higher rate than articles of a less dangerous or perishable nature." (3)

"The liability of the carrier as an insurer of freight against all loss, except such as is occasioned by the act of God or of the public enemy, is elementary, and the greater the value the greater the risk." (630)

**§613 Relation of Terminal Charges to Distance.**—"Every rate comprehends two terminal charges, the initial and the final, and a distance haulage charge." (551) The two terminal charges, however, remain the same regardless of the distance.

**§614 Distance Not Always Controlling.**—"Distance is not always the controlling element in determining what is a reasonable rate."

(632) "Mileage, regardless of other conditions, cannot be made the controlling factor in determining the lawfulness of rates." (634)

**§615 Cost Per Mile Does Not Necessarily Increase With Distance.**—"The expense of transportation does not increase in proportion to the distance, many of the elements which unite to make up the cost of handling freight being the same whether the terminal points be more or less widely separated." (628)

**§616 Rates Are Not Proportioned to Distance.**—"The doctrine that transportation charges should be in proportion to the distance between different points, when these distances are greatly dissimilar, has never been advanced by the railroads or recognized by the Commission. The whole practice of rate making is opposed to the principle of exact proportion, and even in theory there is little reason for its adoption." (638) "It is a cardinal principle of rate making that a rate for a longer distance should be proportionately smaller than for a shorter distance." (551)

**§617 Increase of Distance Must Generally Be Considered.**—"It is undoubtedly true that there are many instances in which the element of distance may be overcome by other considerations, but distance is an important element in the determining of rates and, in the absence of other influences, a controlling element." (645)

**§618 Short Haul May Cost More Than Long Haul.**—"Substantial dissimilarity of circumstances and conditions may justify common carriers in charging greater compensation for the transportation of like kinds of property for a shorter than for a longer distance over the same line." (423)

**619 Status of Ton-Mile.**—"The rate per ton-mile is not always the measure of a reasonable rate, and, rigidly applied, would make distance alone the gage for transportation charges, but it is always valuable as affording a basis of comparison for relative rate burdens." (656)

**§620 Ton-Mile Basis No Test for Local Rates.**—The ton-mile basis "cannot as a rule be considered as a test in railroad operations in case of local rates." (629)

**§621 Judicial Recognition of Ton-Mile Basis Limitations** (538).—The ton-mile ignores:

1. Switching, demurrage and storage.
2. Differences in risks in the character of the freight handled.
3. Quantity, i. e., makes no distinction between car-load and less than car-load shipments.

4. Length of haul.
5. Time required in transportation.
6. Terminal expenses generally.

**§622 Advantage of Natural Location Must Be Recognized.**—"A place is entitled to its natural advantages and a carrier may not deprive it of these advantages which fairly belong to it and because of which investments have been made at this point for the purpose of carrying on production in a more profitable manner than could be done elsewhere." (631)

"Each locality competing with others in a common market is entitled to reasonable and just rates at the hands of the carriers serving it and to the benefit of all its natural advantages." (641)

**§623 Advantages of Natural Location Must Not Be Neutralized.**—"That rates should be fixed in inverse proportion to the natural advantages of competing towns, with a view of equalizing commercial conditions, is a proposition unsupported by law and quite at variance with every consideration of justice. Each community is entitled to the benefits arising from its location and natural conditions, and any exaction of charges unreasonable in themselves or relatively unjust, by which those benefits are neutralized or impaired, contravenes alike the provisions and policy of the statute." (638)

**§624 Natural Advantages Must Not Be Discriminated Against.**—"The offsetting of natural disadvantages at one place as compared to like business at another, by discrimination in freight charges, is inconsistent with the equality provisions of the statute." (643)

**§625 Lawful to Consider Competition.**—"Competition between rival routes is one of the matters which may lawfully be considered in making rates for interstate commerce." (423, 463)

**§626 Test for Competition.**—"Competition must be material and substantial, not artificial or merely conjectural." (447)

"One transportation route or one transportation system should never be allowed to take from another route or system, merely as a consequence of competition, traffic which the latter route or system can carry at less expense." (63)

**§627 Competition as a Regulator of Rates.**—"One test for a reasonable rate is to inquire what has been the result of competition between different carriers; when several different lines of railway could, and did, bid for the same traffic, at what price have these carriers transported that traffic? While not conclusive, this is certainly

important in attempting to determine what is a reasonable charge." (651) "Competition which has been conducted in a normal manner over a period of several years may be assumed to have established a fair relation of rates." (63)

**§628 One Rate Cannot Be Considered by Itself.**—"The question of the reasonableness of a rate on a single article of traffic is one of almost insuperable difficulty." (654) "A freight rate can seldom be considered 'in and of itself.' It must be taken almost invariably in relation to and in connection with other rates." (647)

**§629 "What the Traffic Will Bear" Defined.**—"This is the system of making rates to develop business. It means charging what the shipper can afford to pay. It is rather an excuse for low rates upon cheap goods than for high rates upon dear goods. The traffic manager adopts no fixed standard, but endeavors to ascertain what different classes of goods cost to produce, the demand for them, and their prices in different places, in order to determine what they are able to pay and whether lowering the rate will increase traffic." (3)

"It cannot be said that railroads make tariffs. They only adjust them to varying conditions. Adjusting freight rates is practical work of men who have special training for it and large experience."

**§630 Judicial Recognition of "What Traffic Will Bear."**—"No better rule for the government of a public commission or a court when instigating rates can be adopted than one applied by the railroads themselves, a rule which will adjust rates so as to secure the largest interchange of commodities, a rule which will stimulate, encourage and induce the movement of any commodity which can be produced in any section of the country in large quantities. Of course such rates should not be established so low as to impose an unreasonable burden on other traffic, but should be fixed 'so as to have reasonable relation to the cost of production, and the value of the transportation service to the purchaser and shipper.'" (576)

**§631 What the Traffic Will Not Bear.**—There is a vast difference between charging what the traffic will **not** bear and charging what it **will** bear. The former cuts off business and decreases earnings; the latter will increase business and earnings.

"There will be no shipments if the shipper is charged **more** than the service is worth to him. There will be no inducements to shipments if he is charged **all** the service is worth. There will be an inducement to continued shipments if he is charged **less** than the service is worth." (3)

**§632 Reasonable Rate Includes Profit.** — "Except in unusual cases, no rate is reasonable which does not yield a fair profit upon the transaction." (650)

**§633 Exception to Profit Requirement.**—"Rates must be reasonable, not only to the company, but also to the public. The fact that they do not prove remunerative to a new road built thru a sparsely settled country, where there is at present little local business, does not require the few people to pay such rates as will make the road immediately profitable to its stockholders." (533)

Engineering is the art of directing the great sources of power in nature for the use and convenience of man.
—Tredgold.

# Chapter 14

## ENGINEERING DATA PERTAINING TO UTILITY REGULATION, VALUATION AND DEPRECIATION PROBLEMS

**§634 Candle Power.**—When illuminating gas—which was the first illuminating Utility service—was introduced, it was placed in direct competition with candles. In order that a comparison might be made between the relative worth of gas and candles, the illuminating strength of the new gas was measured in terms of the illumination produced by a candle. Thus, a 16-candle power gas produced 16 times as much light as its competitor, the candle. A candle power hour is simply one candle power of light for one hour.

**§635 Standard Candle.**—The original standard, and the one still used in practical gas work, is the British candle made from spermaceti, carefully prepared from the oil of the whale. Each candle weighs 1200 grains and burns at the rate of 120 grains per hour in a quiet but pure atmosphere. The candle is .8 inch in diameter at the top, .9 inch diameter at the bottom, about 10 inches long, and the standard flame height is 1¾ inches. The light is measured in a horizontal direction.

**§636 Defects of the Standard Candle.**—As a scientifically correct primary standard of light for testing all forms of illuminants, the standard candle is not satisfactory and is not used for such exacting service. Its defects are:

1. Difficulty in securing uniform materials for making the candle.
2. Irregularities in weaving the wick.
3. Variation in shape and length of wick.
4. Very susceptible to atmospheric conditions such as heat, moisture and carbon dioxide.
5. Impossible to correct for the imperfections.

**§637 Candle Power Standard.**—The only primary standard that has found extensive and international use is the Hefner amyl-acetate

lamp. This is a specially constructed lamp burning amyl-acetate at a definite rate with a definite height of flame and definite condition regarding air pressure and humidity.

The United States Bureau of Standards has adopted the Hefner lamp as its primary standard, and 1 Hefner unit is equal to .88 British candle power.

**§638 Candle Power Determination.**—The candle power of any illuminant may be determined by the use of an apparatus known as a photometer.

**§639 Nature of Light.**—Light is a form of radiant energy. This energy is transmitted thru the ether by regular motions. Its perception by the eye is due to the mechanical action of these ether disturbances or motions upon the extension of the optic nerve, forming the sensitive surface of the retina.

**§640 Light Ray.**—This is but an expression for the direction in which ether motion is propagated.

**§641 Light Beam.**—A collection of parallel rays is called a beam.

**§642 Physiological Action of Light.**—Light is not a physical quantity but it is a physiological effect—see §639—exerted upon the eye by a certain narrow range of frequencies of radiation. Frequencies lower than those visible to the eye and frequencies higher than those visible to the eye of course are not perceptible. (44)

**§643 Eye Fatigue.**—"By exposure for a considerable period to the fairly high illumination required when working by artificial light, the sensitivity of the eye decreases, the illumination appears less bright, and thus a higher illumination is required than would be sufficient in the absence of fatigue. The continuous use and absence of rest causes the sensation of strain. If, however, the eye can rest even momentarily by a change to a lower intensity of illumination, fatigue is decreased." (56)

**§644 Uniform Illumination Wrong.**—"Uniform intensity of illumination appears glaring and uncomfortable. For satisfactory illumination, not only is it necessary to provide a sufficiently high intensity at the place where needed, but it is just as necessary to keep the intensity of illumination as low as permissible, wherever it is not needed, so as to afford to the eye rest from fatigue." (56)

**§645 Law of Light Radiation.**—Light radiates in every direction from its source.

**§646 Law of Inverse Squares.**—The intensity of light varies inversely as the square of the distance from the source. This is graphically shown at A of Fig. 44, p. 205.

# FIG. 44

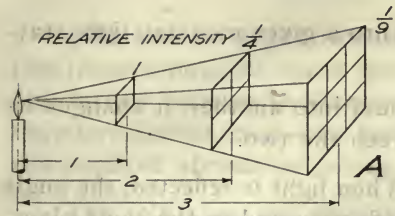
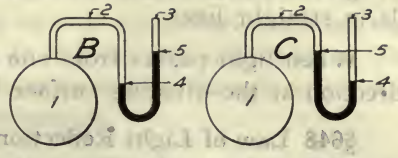


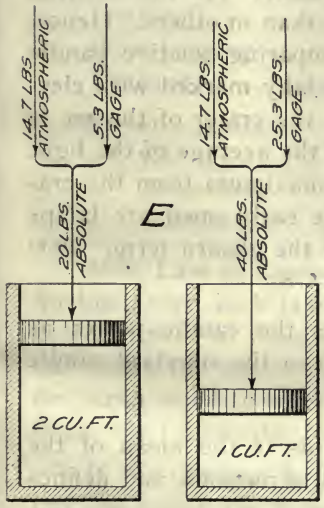

DIAGRAM ILLUSTRATING LAW OF INVERSE SQUARES



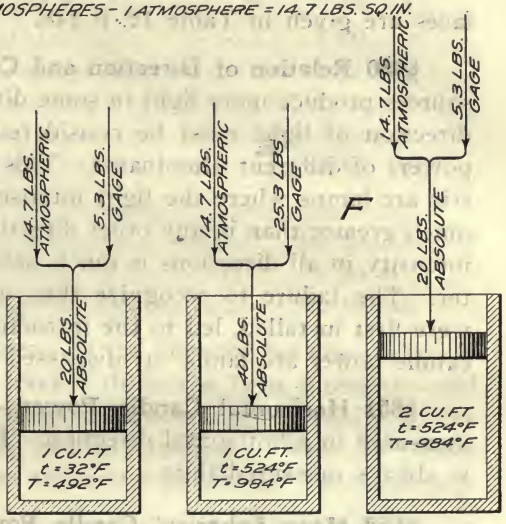

U TUBE PRESSURE GAGE

U TUBE VACUUM GAGE

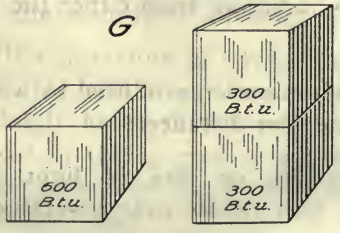
D - GAS PRESSURE UNITS
- 1-FLUID { MERCURY, WATER, ALCOHOL } MEASURED IN INCHES OR MILLIMETERS
- 2-SPRING GAGE { POUNDS PER SQ. IN., OUNCES PER SQ. IN.
- 3-ATMOSPHERES - 1 ATMOSPHERE = 14.7 LBS. SQ. IN.



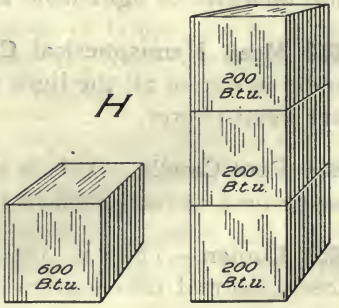

EFFECT OF ABSOLUTE PRESSURE ON GAS VOLUME




EFFECT OF ABSOLUTE TEMPERATURE ON VOLUME OR PRESSURE OF GAS




EFFECT OF ABSOLUTE PRESSURE ON NUMBER OF HEAT UNITS CARRIED BY GAS PER CU.FT. AT CONSTANT TEMPERATURE




EFFECT OF ABSOLUTE TEMPERATURE ON NUMBER OF HEAT UNITS CARRIED BY GAS PER CU.FT. AT CONSTANT PRESSURE

**§647 Laws of Light Direction.**—Thru a given medium, light travels in straight lines.

When light passes from one medium into another, it changes its direction at the dividing surface between the two.

**§648 Law of Light Reflection.**—When light is reflected, the angle of incidence is equal to the angle of reflection and in the same plane.

**§649 Law of Light Interception.**—Rays of light falling on a surface are reflected, absorbed or transmitted, depending on the nature of the substance of which the surface is composed.

The reflecting and absorbing powers of some representative surfaces are given in Table 12, p 248.

**§650 Relation of Direction and Candle Power.**—All illuminating sources produce more light in some directions than in others. Hence, direction of light must be considered in comparing relative candle powers of different illuminants. This is especially marked with electric arc lamps where the light intensity from the crater of the arc is much greater than in any other direction, and the average of the light intensity in all directions is much below the maximum from the crater. The failure to recognize this, when the early open arc lamps were first installed, led to the introduction of the absurd term, "2000 candle power arc lamp," as discussed in §666-7-8.

**§651 Horizontal Candle Power.**—This is the candle power as measured in a horizontal direction. The light of the standard candle is always measured thus.

**§652 Mean Spherical Candle Power.**—This is the mean of the candle power of the light rays radiating in all directions, and defines the total quantity of light from a given source.

**§653 Mean Hemispherical Candle Power.**—This is the mean of the candle power of all the light rays radiating from either the upper or lower hemispheres.

**§654 Foot Candle.**—This is the illumination produced by a standard candle on a normal surface at one foot distance.

**§655 Lumen.**—This is the quantity or flux of light which produces a normal illumination of 1 foot candle over a surface of 1 square foot.

**§656 Light Intensity.**—This is the relative amount of luminous energy given off by any source, i. e., the candle power on the basis of a certain direction.

**§657 Correct Light Intensity.**—At 1 or 2 foot candles of subjective illumination, the eye is working so near its normal condition that any further increase in illumination is of relatively small value. The objective illumination—see §660—must be strong enough to produce the required normal subjective illumination.

The following are some typical objective foot candle intensity requirements:

| | |
|---|---|
| General Illumination: | |
| Auditoriums | 1 to 3 |
| Theaters | 1 to 3 |
| Stores | 3 to 4 |
| Residences | 2 to 5 |
| Libraries | 1 to 2 |
| Reading | 1 to 3 |
| Book-keeping | 3 to 5 |
| Drafting | 5 to 10 |
| Street Lighting: | |
| Gas | .05 to .25 |
| Electricity | .05 to .6 |
| Full Moon | .02 to .03 |

**§658 Law of Lamp Distances.**—If the distance between lamps is doubled, then each lamp must have 4 times the light intensity—and power input—to maintain the same minimum light intensity. This will halve the number of lamps, but will require 4 times the power per lamp and hence will require twice the power for the same minimum light intensity.

If the distance between lamps is halved, then each lamp needs but one-fourth the light intensity to secure the same minimum light intensity. This will double the number of lamps, but as each lamp will require only one-fourth the power, the total power to secure the same minimum light intensity will be halved.

"It is therefore of advantage to use as many units of illuminants as possible, and bring them together as close as possible, and correspondingly lower their intensity, up to the point where the increasing cost of taking care of a larger number of units, and increasing cost of poles and connections compensates for the decreasing cost of energy." (56)

**§659 What Is Illumination?**—Illumination is the generic term for the effects caused or produced by the action of light. There are two distinct species, namely: objective illumination and subjective illumination.

**§660 Objective Illumination.**—This is the number of foot candles of light that are thrown on the object to be illuminated by the light source. This is governed by the law of inverse squares—see §646.

"It is not light that is wanted, but illumination; it is not the amount of visible rays issuing from the source of light that is of importance, but the amount of light which reaches the objects we desire to see—that is, the illumination produced by light." (44)

**§661 Effects of Objects on Resulting Illumination** (44, 56).—Illumination is a quantity which depends not only on the source of light, but also on the illuminated objects and their nature. It is not the amount of light which reaches the illuminated objects which is of importance—that is, not the physical intensity of illumination—but the amount of light which from these objects reaches the eye. Thus, with the same number of candle feet of illumination per unit of area, one object may appear bright and another dark, since the same light may produce radically different effects with different light-reflecting objects, as shown in Table 12, p. 248.

**§662 Subjective Illumination.**—This is the physiological effect produced by light with regard to clearness, comfort and satisfaction. (56)

**§663 Physiological Action Is Illumination Criterion.**—It is the subjective illumination by which the success of an illuminating problem is judged. Illumination may be very satisfactory or it may be entirely unsatisfactory, depending on whether the physiological requirements are satisfied or violated. (56)

**§664 Intrinsic Brilliancy.**—This is the number of candle power per square inch. Physiologically, the brilliancy of the light source is one of the most important quantities on account of the inevitable eye fatigue resulting from excessive brilliancies in the path of vision.

The maximum light brilliancy which the eye can withstand without bad effects is 4 candles per square inch. The greater the brilliancy, or the greater the area of the source with the same brilliancy, the more the eye will be affected. (56)

**§665 Color.**—The following are the colors of typical light sources:

| | |
|---|---|
| Acetylene | Nearly white. |
| Electric Arc Light: | |
| Open | White. |
| Enclosed | Bluish white to violet. |
| Flaming | Yellowish orange. |
| Magnetite | Bluish white. |
| Candle | Orange yellow. |
| Carbon filament, below normal voltage | Orange to orange red. |
| Carbon filament, above normal average | Yellowish white. |

| | |
|---|---|
| Gas Light: | |
| Open flame | Pale orange. |
| Welsbach mantle | Greenish white. |
| Kerosene lamp | Orange. |
| Nernst " | Very nearly white. |
| Tungsten " | Very nearly white. |
| Mercury " | Bluish green. |
| Sun, high in sky | White. |
| Sun, near horizon | Orange red. |

**§666 Term "2000 Candle Power Arc Lamp" Is Misnomer.**—This is an unfortunate and misleading term that is really only a trade name for the—now obsolete—9.6 ampere, carbon, direct current, open arc lamp, universally used when electric arc lighting was first introduced. In the Colorado Springs lighting controversy (13) "it was admitted at once by all the experts that this term must be taken in a Pickwickian sense, and by no means represented the actual measurement of the candle power." (729)

**§667 How "2000 Candle Power" Term Originated.**—"When the arc lamp first made its appearance it wholly baffled the attempts of photometrists, with the means then at their disposal, in their attempts to give even an approximate idea of its actual light-giving power. It is related that, when one of the first commercial arc lamps was completed, it was examined by a college professor, who was asked to give an estimate of its candle power. He replied in an off-hand manner that he thought it would run about 2000; and an open arc lamp of that particular type has been called a 2000 candle power lamp ever since. Altho it was soon learned that such a rating was enormously exaggerated, the fiction, having once come into use, persisted to such an extent as to find its way into many lighting contracts." (730)

**§668 Substitutes for "2000 Candle Power Arc Lamp."**—Since this term is in no way an indication of the real illuminating value of the lamp, it has been the cause of many controversies where the term is used in street lighting contracts, especially where other lamps have been substituted.

"In the Colorado Springs lighting controversy (13) it was found that 6.6 ampere a. c. enclosed arcs as commercially operated were not a fair substitute for the arcs designated as having a nominal rating of 2000 candle power. The difference which the arbitrators found was 20 per cent. The arbitrators also found—considering the opinions of all the experts—that it was quite conclusive that a 7.5 ampere a. c. enclosed arc lamp would be a fair substitute for the '2000 candle power arc.'" (733)

**§669 Wattage Is Not Only Basis for Arc Lamp Rating.**—"Illuminating engineers are by no means agreed that the wattage—see §747—basis is the proper basis for rating arc lamps. There are other factors which influence the amount of illumination furnished by a lamp, such as the amount of current flowing, the adjustment of the mechanism of the lamp, the height of the arc in the lamp, the amount of deposit on globes, the kind of carbons, globes and reflectors used." (729)

**§670 Atmospheric Pressure.**—The atmosphere exerts a pressure in all directions; the intensity of this pressure is dependent on the density of the air. The air density varies with the altitude and temperature, and the higher the altitude or temperature, the lower will be the air density.

Sea level is the datum from which atmospheric pressures are reckoned. At that point dry air at 32 degrees F. exerts a pressure of 14.7 pounds per square inch.

**§671 Barometric Pressure.**—Atmospheric pressure is measured by a barometer, and is synonomous with barometric pressure. The barometric pressures corresponding to different altitudes are shown in column B of Table 11, p. 248.

**§672 Gage Pressure.**—This is simply the pressure indicated by a pressure gage.

**§673 Absolute Pressure.**—This is the sum of the gage pressure and the barometric pressure. Thus, if the gage pressure is 2 inches of mercury and the barometric pressure is 29 inches, then the absolute pressure will be $2 + 29 = 31$ inches of mercury.

**§674 Fluid Gages for Gas Pressure Measurement.**—Fluid gages are also known as manometers, the simplest form of which is the U glass tube shown at B in Fig. 44, p. 205. When no pressure is applied other than the prevailing atmospheric pressure, the liquid will stand at the same level in tubes 2 and 3. When the gas main, 1, is under pressure above the atmosphere, the liquid will be lower in 2 and raised in 3. The difference in levels 4 and 5 is then the fluid pressure in 1.

A vacuum gage is shown at C in Fig. 44, p. 205. If 1 is at less than atmospheric pressure, then the fluid will stand higher in 2 than in 3, and the difference in levels 4 and 5 indicates the vacuum in 1.

**§675 Choice of Fluids.**—This is determined by the pressure to be obtained, the fluid of greater density being required for the higher pressures. See Table 9, p. 247.

The advantages of alcohol are that it will give a higher reading for the same pressure and, being free from solid matter, the glass tubes will remain clear and make it easier to secure accurate readings. The alcohol pressure readings in inches multiplied by the specific gravity of the alcohol used, will give the equivalent pressure readings in inches of water.

**§676 Gas Pressure Units.**—These are classified as shown in D of Fig. 44, p. 205. Their numerical relations are shown in Table 9, p. 247.

**§677 Differential Pressure.**—This is the difference between the pressure at the inlet and outlet point of a gas line. Thus, if the inlet pressure is 6 oz. and the outlet pressure is 4 oz., the differential head, or pressure, is 2 oz. In gas transmission it is the differential pressure that constitutes the effective force for pushing the gas thru the line.

**§678 Factors Affecting Gas Pressure.**—"In order to distribute gas satisfactorily, it must be put under considerable pressure at the holder or other center of supply in order to overcome the friction of the gas in the mains and service pipes, to operate the meter, to force the gas thru the consumer's house piping and to overcome differences in elevation between the point of supply and point at which the gas is used. The amount of this initial pressure depends upon the size and length of the gas main, the specific gravity of the gas, the size and length of the service pipe and house piping, the pressure required to operate the meter, the condition of the interior surface of the mains and pipes, the number of bends and other fittings in the line, the amount of gas consumed, the pressure desired at the consumer's burners or gas appliances, the difference in elevation between the point of supply and the point at which the gas is used." (685)

"The gas pressure at any point depends also upon the amount of gas flowing thru the pipe, as well as upon the initial pressure. Thus, if a certain pressure is to be constantly maintained at a certain point in the distribution system, the initial pressure at the point of supply will have to be changed every time the consumption changes appreciably, more pressure being required to overcome the friction in the mains as the consumption increases. Now, while it is possible to maintain a certain pressure at one point by changing the initial presure to suit the load, it is at once apparent that the pressure in the main near the point of supply would vary, and thus while certain consumers would have perfect service, others along that line might be subjected to varying pressure." (685)

**§679 Minimum Pressure.**—"The pressure at the consumer's end of the company's service pipe should never be less than 2 inches water." (685)

**§680 Maximum Pressure.**—"It is not practicable for a consumer to increase the pressure at which gas is supplied to him, but he can reduce pressure within certain limits. However, the burners and appliances in general use at present are not designed to be used at a pressure of more than 6 inches water, and a higher pressure would result in unsatisfactory service. It would also increase the danger from leaks in the meter or in the house piping, and would result in a larger consumption of gas without corresponding benefits to the consumer." (685)

**§681 Effect of Elevation on Gas Pressure.**—Excepting gasoline gas, all commercial gases are lighter than air—see §730—and when confined in a closed pipe, tend to increase in pressure as the elevation increases, due to the buoying action of the column of air which is heavier than the equivalent column of gas. This is why gas holders are always placed in the lowest part of a gas distributing system.

The effect of elevation may be considerable, but is more marked at low than high pressures. With artificial gas, an increase of 100 feet elevation will increase the pressure approximately .5 inches of water. With a normal distributing pressure of 2 inches of water, this would produce a pressure increase of 25 per cent, while with a distributing pressure of 10 inches of water the increase would be only 5 per cent. The topography of the distributing district must be considered in all low pressure gas problems, and a uniform pressure over an entire district may be an impossibility.

**§682 Effect of Pressure on Gas.**—For engineering purposes, at a given constant temperature, the volume of a gas is inversely proportional to the absolute pressure—see §673—to which the gas is subjected. That is, the product of the absolute pressure and the volume of a given mass of gas remains constant.

Let V = volume at absolute pressure P.

Let v = volume at absolute pressure p.

Then V : v : : p : P or V P = vp.

This is illustrated in E of Fig. 44, p. 205, and in Table 10, p. 247.

**§683 Gas Storage in Pipe Lines.**—The gas storage capacity of various size gas mains is shown in Fig. 47, p. 251. These values were computed by the application of the law stated in the preceding section. Thus, the gas at 4 oz.—.25 lb.—gage pressure equivalent to

that contained in 1 mile of 24 inch main at 250 lbs. gage pressure and 14.4 lbs. atmospheric pressure may be computed as follows:

$P = 250 + 14.4 = 264.4.$
$p = .25 + 14.4 = 14.65.$
$V =$ volume in cu. ft. of 24" line 1 mi. long $= 16590.$
$v =$ unknown.
$vp = P\,V.$

$$v = \frac{PV}{p} = \frac{264.4 \times 16590}{14.65} = 299395 \text{ cu. ft.}$$

**§684 Effect of Fluctuating Pressure on Gas Service.**—The relation of pressure and candle power of Welsbach mantles is as follows:

| Pressure in Inches of Water. | Candle Power. | Gas Consumption Per Hour. Total. | Per Candle Power. |
|---|---|---|---|
| 1.2 | 40 | 3.8 cu. ft. | .095 cu. ft. |
| 2 | 78 | 4.9 cu. ft. | .063 cu. ft. |
| 2.8 | 107 | 6 cu. ft. | .056 cu. ft. |

**§685 Temperature.**—Temperature is analogous to pressure in gases, in that it indicates degree or intensity, but is not synonymous with heat because it does not indicate the quantity of heat.

**§686 Temperature Scales.**—The degree of temperature is measured by either the Centigrade or Fahrenheit scales. Their relation is as follows:

| | Centigrade. | Fahrenheit. |
|---|---|---|
| Freezing point of water..... | $0^0$ | $32^0$ |
| Boiling point of water..... | 100 | 212 |
| Absolute zero ..... | -273 | -460 |

$$F = \frac{9}{5} C + 32$$

$$C = \frac{5}{9} (F - 32)$$

**§687 Absolute Temperature.**—The real starting point for gas activity is not at the ordinary zero point, but at absolute zero, which is $460^0$ below zero, or $492^0$ below freezing on the Fahrenheit scale.

Absolute temperature is the temperature reckoned from absolute zero. Thus, let T = absolute, and t = observed temperature Fahrenheit. $T = 460 + t.$

**§688 Effect of Temperature on Gas.**—At a given constant pressure the volume of a given mass of gas is directly proportional to its absolute temperature. That is, the volume of any gas free to expand, or the pressure of any confined gas, increases or decreases just as its absolute temperature increases or decreases. Thus, let

$T_1$ = absolute temperature at volume $V_1$ and pressure $P_1$.

$T_1$ = absolute temperature at volume $V_1$ and pressure $P_1$.

$$\text{Then, } \frac{VP}{T} = \frac{V_1P_1}{T_1}$$

This is graphically illustrated in F of Fig. 44, p. 205.

The volume or pressure of gas will vary approximately 1 per cent for each 5° change.

**§689 Standard Conditions.**—Since the volume of a gas varies with the temperature and pressure, in order to secure comparable result in gas calculations, and the establishment of standards, a standard condition is necessary. This is usually taken at 32° Fahrenheit and a pressure of 29.90 inches of mercury.

**§690 Effect of Altitude on Gas Apparatus Capacity.**—This is shown in Table 11, p. 248, where column C represents the decrease in gas apparatus capacity at various altitudes on the basis of 100 per cent capacity at sea level. Thus, a gas engine or gas producer rated at 100 H P at sea level, will produce only 83.1 per cent of sea level rating, or 83.1 H P, when used at an elevation of 5,000 ft.—which is approximately the altitude of Denver, Colorado.

The practice of rating apparatus for the manufacture, handling or use of gas on a sea level basis—for the reasons given in §689—is almost universal. Hence, the effect of altitude on plant capacity should always be known and considered. Even at an elevation of 1,000 feet—which embraces the major portion of the United States—the plant capacity will be only 96.3 per cent of the sea level rating.

**§691 Effect of Temperature or Pressure Changes on Heating Value of Gas.**—These will produce changes in volume, but will neither destroy nor create any heat units, and hence will neither increase nor decrease the total number of heat units contained in gas. However, the volumetric changes will always alter the distribution of the total number of heat units as illustrated in G and H of Fig. 44, p. 205. Thus, if the absolute pressure is halved—under constant temperature—the volume will be doubled and the 600 heat units distributed thru 2 cubic feet or 300 B. t. u. per cubic foot. If the tem-

perature is raised from 32° F. to 1016° F., the volume will be trebled and the 600 heat units distributed thru 3 cubic feet or 200 B. t. u. per cubic foot.

**§692 Heat Unit.**—The unit quantity of heat, or the heat unit, is the heat required to raise the temperature of a unit weight of water one degree.

The heat required to raise one pound of water one degree Fahrenheit is called a British thermal heat unit, and abbreviated B. t. u.

**§693 Heating Value.**—This is the number of heat units that are evolved by the combustion of a unit weight or volume of fuel. The terms "calorific value," "calorific power," "heating power," "thermal value," and "heat of combustion" are frequently applied to the same phenomenon.

**§694 Calorific Intensity.**—The calorific intensity of a fuel is the theoretical maximum temperature that may be obtained by burning the fuel under any given conditions. It is not proportional to the calorific power, and will vary with the conditions under which combustion takes place.

**§695 Latent Heat of Evaporation.**—The latent heat of evaporation of a body is the amount of heat required to change the body from a liquid to a vapor, without change of temperature. The latent heat of water or water vapor is 966 B. t. u. per pound.

**§696 Gross or High Heating Value of Gas.**—This is simply the total number of heat units evolved in the combustion of a unit volume of gas.

**§697 Net, Low or Effective Heating Value of Gas.**—Gases containing hydrogen or compounds of hydrogen always form steam when burned. If this steam is not condensed, so as to conserve its latent heat of evaporation—see §695—the heat available from the combustion conditions will be below the gross heating value by an amount equal to the latent heat lost in steam. Thus, 966 B. t. u. will be lost for every pound of steam that escapes.

The heat units remaining after deducting the latent heat loss will be the net, low or effective heating value of the gas, thus: Net heating value = Gross heating value —latent heat in steam.

**§698 Combustion.**—Combustion is a vigorous chemical combination attended by the evolution of heat and light. It may also be defined as the burning or chemical combination of the constituents of fuel, mostly carbon and hydrogen, with the oxygen of the air.

**§699 Commercial Gases.**—These are not definite chemical compounds, but mechanical mixtures made up of aplurality of constituents, the number of the constituents and their proportion being dependent upon the method of manufacture and nature of raw fuel.

**§700 Hydrogen, Symbol H.**—This is colorless, odorless, nonpoisonous, very combustible, burns with a pale blue, nearly nonluminous flame, and is the lightest known substance.

**§701 Marsh Gas, Symbol C $H_4$.**—This is sometimes called methane, and is the main constituent of natural gas. It is colorless, slightly soluble in water, odorless, has a high heating value, and burns with a slightly luminous flame.

**§702 Olefiant Gas, Symbol $C_2$ $H_4$.**—This is sometimes called ethene or ethylene, and is the main illuminating constituent of coal gas. It is colorless, odorless, has a high heating value, and burns with a highly luminous flame.

**§703 Carbon Monoxide, Symbol CO.**—This is also known as carbonic oxide. It is odorless, a deadly poison, colorless, practically insoluble in water, has a low heating value and burns with a distinctive pale blue flame.

**§704 Carbon Dioxide, Symbol $CO_2$.**—This is also called carbonic acid and carbonic anhydride. It is non-combustible, colorless, odorless, soluble in water, and is a worthless constituent of any gas.

**§705 Oxygen, Symbol O.**—This is tasteless, odorless, invisible, non-combustible in itself and is a useless constituent.

**§706 Nitrogen, Symbol N.**—This is colorless, odorless, non-combustible and exerts no influence except to act as a diluent. Hence it is a worthless constituent.

**§707 Atmospheric Air.**—This consists of a mixture of oxygen and nitrogen with small quantities of ammonia, argon, carbon dioxide and water vapor, the amount of the latter depending upon the temperature and relative humidity of the atmosphere. Pure dry air consists, by volume, of 23.15 per cent oxygen and 76.85 per cent nitrogen.

**§708 Naphthalene, Symbol $C_{10}$ $H_8$.**—This is frequently troublesome in retort coal gas plants. It is solid at ordinary temperatures, but will exist in a state of vapor suspended in gas at temperatures even far below that at which it solidifies—which is at 176° F.—if the gas is not saturated with it.

When saturation is reached, the vapor will pass directly into the solid state in the form of very light, flat, flaky crystals, frequently causing clogging of pipes.

**§709 Hydrocarbons.**—There are about 200 species of compounds consisting only of hydrogen and carbon, known as hydrocarbons. They exist in gaseous, liquid and solid states; some have a tendency to condense, and the clogging of gas fixtures is caused by their precipitation.

**§710 Illuminants.**—This means substances—generally hydrocarbons—that make a gas flame luminous. Olefiant gas is sometimes included in this term.

**§711 Natural Gas.**—This is made by a secret process of nature; the principal constituent is marsh gas, and the exact composition varies with different localities. The scientists who have made a special study of nature's process do not agree on the method of production, and since gas is secured from different geological formations in different fields, it makes the definite settling of this question even more doubtful. However, all facts indicate that nature's process is a slow one, and that, therefore, if there will be any regeneration in the present depleted fields, the rate of regeneration will be so slow as to make the gas pools formed of no value or interest for generations.

**§712 Retort Coal Gas.**—This is made by subjecting bituminous coal to destructive distillation—i. e., heating without access of air—in externally heated, air-tight retorts holding about 400 pounds of coal. The resulting gas is withdrawn from the retorts by an exhauster. When the distillation is completed, a residue of coke is left in each retort and this is then removed and the retort refilled with a fresh charge.

The term "bench gas" is also correctly applied to this gas, and refers to the benches which holds the retorts. The terms "illuminating gas," "town gas," "city gas," and "artificial gas" are sometimes incorrectly applied to this gas; those terms are defective in that they are generic rather than specific.

2,000 lbs. Pittsburg coal will yield about:

9,800 cu. ft. 15 candle power gas.
1,100 lbs. clean coke.
200 lbs. breeze coke and dust.
1 lb. retort carbon.
5 lb. ammonia.
12 gal. tar.

**§713 Coke Oven Gas.**—This is made in a by-product coke oven, i. e., the gas evolved by the distillation of the coal in the air-tight ovens is withdrawn and saved. The composition of the gas is sim-

ilar to retort coal gas. There are these marked differences, however, in the processes: First, each oven holds about 50 times as much coal as a retort; second, the gas is the by-product and the coke is the main product, which is just the reverse of the retort coal gas system.

2,000 lbs. good coking coal will yield about:

1,500 lbs. coke.
5 lbs. ammonia.
10 gals. tar.
4,600 cu. ft. 18 candle power gas.

**§714 Producer Gas.**—This is the result of an incomplete combustion, i. e., by operating with a fuel bed so thick that carbon monoxide instead of the usual carbon dioxide is formed. No combustible residue or coke is left—as is the case in retort coal gas or coke oven gas—and the heat required for the gasification is obtained in the interior of the producer by the partial combustion there of a portion of the fuel which is being gasified.

2,000 lbs. of good coal will yield about 140,000 cu. ft. gas containing 144 B. t. u. per cu. ft.

**§715 Water Gas.**—This is produced by bringing water, in the form of steam, into intimate contact with incandescent carbon, the steam decomposing into hydrogen and carbon monoxide. The steam will obviously so chill the carbon that the decomposition cannot take place. Hence it will then become necessary to store more heat in the carbon. This is almost universally done by shutting off the steam and blowing the carbon with air, this bringing it back to incandescence and making it ready for the next steaming; this makes the system intermittent.

The large hydrogen content makes the gas burn with a pale blue, practically non-luminous flame, while the carbon monoxide makes it a deadly poison.

From 50 to 60 lbs. of coke are required per 1,000 cu. ft. of gas.

**§716 Carbureted Water Gas.**—To change the blue flame of water gas to one that will be luminous, various methods are in use for injecting hydrocarbons—as naphtha or oil—into the gas and making it luminous. The resulting mixture is known as carbureted water gas.

The carbureting has no effect on the carbon monoxide, and hence the gas is a deadly poison. A large portion of the artificial illuminating gas sold in this country is carbureted water gas.

About 30 to 40 pounds of coke and 5 gallons oil are required per 1,000 cu. ft. of gas made.

**§717 Oil Gas.**—This is made by vaporizing oil, generally by allowing the liquid to flow thru hot retorts or spraying the oil against red-hot fire brick. About 12 gallons of oil are used per 1,000 cu. ft. of gas made.

**§718 Gasoline Gas.**—This is made by carbureting—i. e., combining—gasoline vapors with air. Since the weight of the vapor is added to the air, the resulting gas will obviously be heavier than air.

One gal. 70° gasoline will make 190 cu. ft. of gas having a heating value of 625 B. t. u. per cu. ft.

**§719 Acetylene, Symbol $C_2 H_2$.**—This is made by bringing calcium carbide in contact with water. One pound of the commercial carbide will produce 4 cu. ft. of gas having a heating value of 1,400 B. t. u. per cu. ft.

The candle power varies with the type of burner and gas consumption per hour.

¼ cu. ft. will produce 12 candle power.
½ cu. ft. will produce 24 candle power.
¾ cu. ft. will produce 36 candle power.
1 cu. ft. will produce 48 candle power.

**§720 Gas Impurities and Diluents.**—These are:

1. Tar. This will condense, causing clogging of pipes, and also absorb illuminants.
2. Ammonia. This is very corrosive on brass and other metals used in gas handling equipment.
3. Sulfur. When burned, this produces fumes that are injurious, not only to metals, but especially harmful to the lungs.
4. Naphthalene. When this crystalizes it will clog pipes.
5. Carbon Dioxide. This is simply a diluent, lowering the candle power and heating value.
6. Air. Merely a diluent.

**§721 Qualitative Test for Tar in Gas.**—Make gas impinge on clean white paper; if tar is present, the paper will become soiled.

**§722 Qualitative Test for Ammonia in Gas.**—Make gas impinge against moistened turmeric paper; if ammonia is present, the paper will turn brown. Blue litmus paper reddened by a weak acid may be used instead of the turmeric paper, and will regain its original blue color if ammonia is present.

**§723 Qualitative Test for Sulfur.**—Make gas impinge on clean white paper; wet with a solution of sugar of lead; if sulfur is present, a dark stain will appear.

**§724 Qualitative Test for Carbon Dioxide.**—Bubble gas thru a clear solution of lime water; if carbon dioxide is present, the water will become cloudy.

**§725 Qualitative Test for Naphthalene.**—First free the gas from tar by passing thru cotton, and from ammonia by bubbling thru a 5 per cent solution of sulfuric acid. Then bubble the gas thru a solution of 20 grains of picric acid in one gill of warm distilled water. A heavy precipitate will appear if the naphthalene is excessive.

**§726 Quantitative Test for Air.**—The determination of the heating value or candle power of the gas will show whether air is present, and in what per cent.

**§727 Vitiation of Air by Gas Fumes.**—Carbon dioxide and steam are always formed when gas is burned, the relative amount of each being dependent on the chemical composition of the particular gas. If safe and hygienic conditions are to be maintained in rooms heated by gas fires, chimney provision must be made for the removal of the combustion products. The so-called odorless, smoke-consuming and chimneyless gas heating appliances are not only frauds, but also a positive menace to health, and ought never be used.

An average person exhales .6 cubic feet carbon dioxide per hour. An ordinary incandescent mantle burner forms about 4 cubic feet carbon dioxide per hour, hence vitiates as much air as six people.

**§728 Heat Loss Due to Steam in Combustion Products.**—When the inevitable water vapor formed by the combustion of gas passes out as steam with the other combustion products, instead of being condensed in the gas heating device, the latent heat of the water—see §695—is lost. Correctly designed gas heating devices must condense the steam so as to retain the latent heat and conserve this heat energy. This loss in the combustion of 1,000 cubic feet of two typical gases is as follows:

| | B. t. u. in gas. | Water in combustion products. | lbs. | Latent heat loss in B. t. u. | % |
|---|---|---|---|---|---|
| Carbureted water gas. | 600,000 | 1080 cu. ft. steam = | 38.9 | 37577 | 6.2% |
| Natural gas ..... | 1,000,000 | 1930 cu. ft. steam = | 69.5 | 67137 | 6.7% |

**§729 Diffusion of Gases.**—By diffusion we understand the mixing of two gases which were previously separated. Experiments have proven that when two or more gases, even with marked differences in density, are brot together, the tendency is for them to become diffused or, what is the same thing, thoroly intermixed.

**§730 Specific Gravity.**—The specific gravity of a gas is the ratio of its density to the density of another gas taken as a standard. It must be borne in mind that the specific gravity of a gas is affected by temperature and pressure, and hence reference to a standard condition is necessary.

The following specific gravities with reference to air as unity and a standard condition of 32° F. and 29.9 in. mercury are typical.

| | | |
|---|---|---|
| Commercial gases: | | |
| Natural gas | | .62 |
| Artificial gases | Gasoline gas | 1.20 |
| | Acetylene | .91 |
| | Producer gas | .88 |
| | Carbureted water gas | .60 |
| | Water gas | .50 |
| | Coke oven gas | .42 |
| | Retort coal gas | .40 |
| Commercial gas constituents: | | |
| Diluents | Carbon dioxide | 1.529 |
| | Oxygen | 1.105 |
| | Nitrogen | .972 |
| Combustible | Carbon monoxide | .967 |
| | Olefiant gas | .967 |
| | Marsh gas | .559 |
| | Hydrogen | .069 |

**§731 Gas Leakage Depends on Density.**—"The relative leakage tendencies of any two fluids under the same conditions are practically inversely proportional to the square roots of their respective densities."

Thus the relative leakage of air and retort coal gas would be inversely proportional to $\sqrt{1} : \sqrt{.4} = 1 : .63$. That is, the leakage tendency of retort coal gas will be $\frac{1.00}{.63} = 1.6$ times that of air under similar conditions.

Water has a density of 819.5 times heavier than that of air. Hence leakage tendency of retort coal gas in comparison to that of water is $819.5 \times 1.6 = 1311$. times that of water. This accounts for the universal difficulty in keeping gases confined without leakage.

**§732 Gas Is Neither Light Nor Heat Per Se.**—Gas simply acts as a carrier of heat or illuminating energy. The consumer's sole object in buying gas is to get the heat or illuminating energy that the

gas carries. Furthermore, in the use—i. e., the burning of gas—it is physically, chemically and practically impossible to produce heat without evolving light or to produce light without evolving heat simultaneously.

**§733 Laws of Gas Flow.—**

Let d = diameter of main.
l = length of main.
p = differential pressure.
s = specific gravity.
Q = quantity.

Q varies directly as $\sqrt{p}$, $\sqrt{d^5}$ and inversely as $\sqrt{l}$ or $\sqrt{s}$
l varies directly as p or $d^5$ and inversely as $Q^2$ or s
s varies directly as p or $d^5$ and inversely as $Q^2$ or l

d varies directly as $\sqrt[5]{Q^2}$ or $\sqrt[5]{l}$ or $\sqrt[5]{s}$ and inversely as $\sqrt[5]{p}$
p varies directly as $Q^2$ or l or s and inversely as $d^5$

**§734 Efficiency.**—This is the ratio of energy input to energy output and, since no man-made apparatus can ever be perfect, its efficiency must always be less than unity. In other words, every transformation of energy necessarily involves more or less loss.

**§735 Horse Power.**—When James Watt introduced the first steam engine, it was placed in direct competition with horses. In order to make a comparison between the work that a horse could do and what his engine would do, Watt made a test and found that the work of the average draft horse was equal to 22,000 ft. lbs. per minute, the ft. lb. being the product of the weight raised by the vertical distance traveled. In order to give a larger margin to his engine rating, Watt arbitrarily increased this 50%, thus making the arbitrary horse power equivalent to 33,000 ft. lbs. work per min. and this is the value that is universally used as a standard for power measurement.

**§736 Indicated Horse Power.**—This is the total power developed by an engine as measured by an "engine indicator." It is abbreviated I. H. P.

**§737 Brake Horse Power.**—This is the power available from an engine, or other prime mover for useful work; it is abbreviated B. H. P. It is the I. H. P. minus the engine friction.

**§738 Circular Mil.**—This is the unit of area for electric conductor measurement and is the area of a circle of 1 mil (.001 of an inch diameter). The area of any electrical conductor in circular mils is equal to the square of its diameter in mils, or one million times the square of its diameter in inches.

**§739 Volt.**—This is the unit of electric pressure, and is analogous to head or pressure of water in hydraulics. High voltages are necessary for long distance commercial transmission of electricity, because "the weight of the conductor for a given power loss per unit of length is inversely proportional to the square of the voltage."

Thus, if A lbs. of conductor are required at 100 volts, XA lbs. will be required at 200 volts, and the value of X will be:

$$(1000)^2 : (200)^2 :: X : A$$
$$40000X = 1000000A$$
$$X = \frac{1000000A}{40000}$$
$$= 25A$$

Thus 25 times more weight of conductor will be required at 200 than at 100 volts.

**§740 Effect of Fluctuating Voltage.**—This is shown graphically in Fig. 45, p. 224.

**§741 Millivolt.**—This is simply .001 of a volt. It is used in sensitive work such as electrolysis surveys.

**§742 Voltage Generally Used for Various Services.**—

| | |
|---|---|
| Telegraph and telephone..... | 25 to 50 volts. |
| Direct current trolley lines..... | 550 volts. |
| Electric lighting ..... | 110 or 220 volts. |
| Electric power ..... | 220, 1100 or 2200 volts. |
| Electric transmission ..... | 1100 volts and upward. |

**§743 Ohm.**—This is the unit of electric resistance, and is analogous to friction in water pipes.

Approximate relative resistivities:

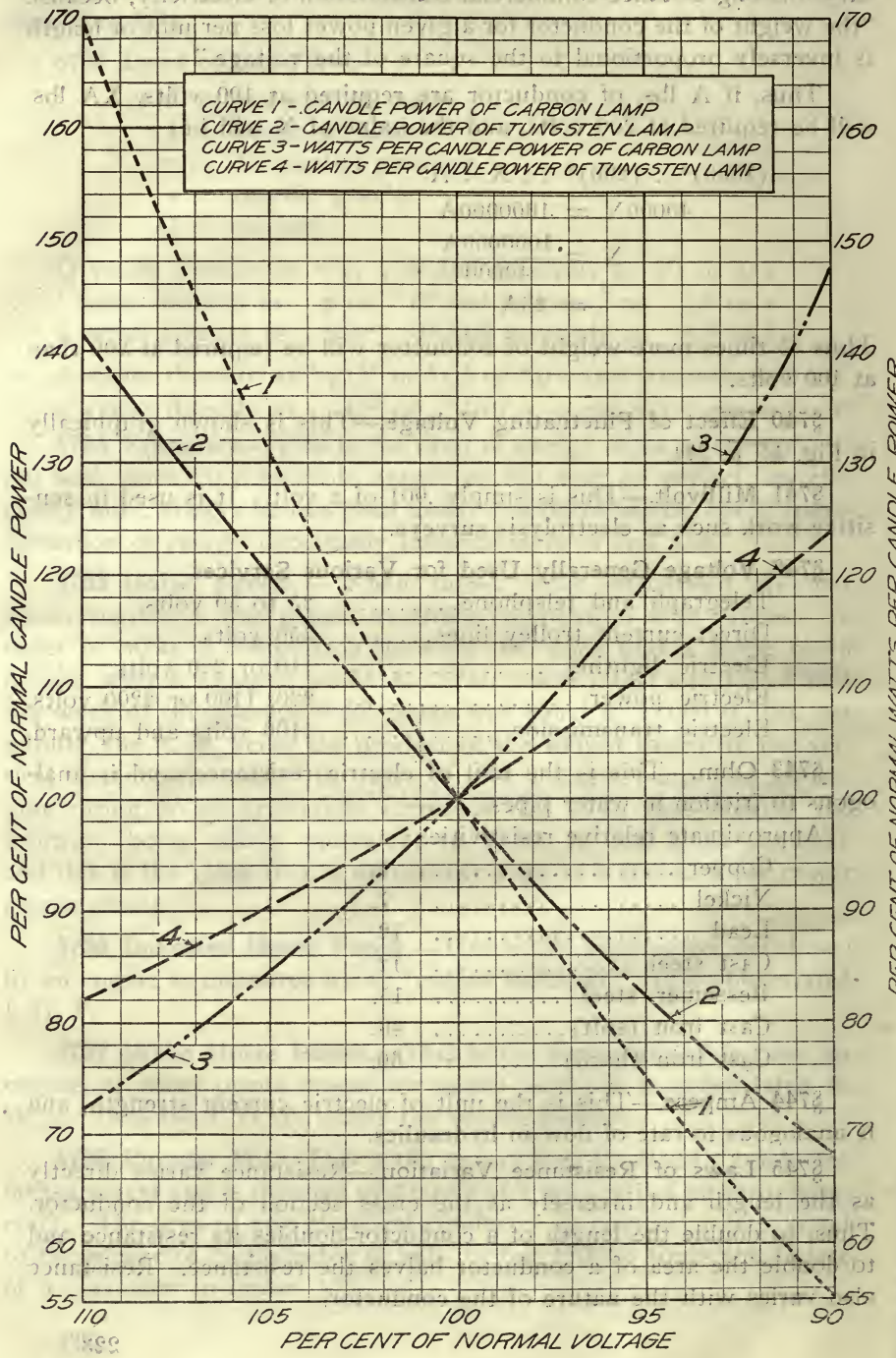
| | |
|---|---|
| Copper ..... | 1. |
| Nickel ..... | 7. |
| Lead ..... | 12. |
| Cast steel ..... | 12. |
| Bessemer steel ..... | 15. |
| Cast iron (soft)..... | 46. |
| Cast iron (hard)..... | 60. |

**§744 Ampere.**—This is the unit of electric current strength, and is analogous to rate of flow in hydraulics.

**§745 Laws of Resistance Variation.**—Resistance varies directly as the length and inversely as the cross section of the conductor. Thus, to double the length of a conductor doubles its resistance and to double the area of a conductor halves the resistance. Resistance also varies with the nature of the conductor.

# FIG. 45

# EFFECT OF VOLTAGE VARIATION ON CANDLE POWER AND EFFICIENCY OF INCANDESCENT ELECTRIC LAMPS



**§746 Relation of Volts, Ohms and Amperes.**—This is expressed by Ohm's law, where current in amperes $= \frac{\text{Volts}}{\text{Ohms}}$

**§747 Watt.**—This is the unit of power and equals the product of volts and amperes. Thus, a current flow of 2 amperes and 100 volts is equal to 200 watts.

**§748 Kilowatt.**—This is the commercial unit of electric power and is equal to 1000 watts; it is abbreviated K. W.

**§749 Kilowatt Hour.**—This is the work done by 1 K. W. working for 1 hour.

**§750 Electric Horse Power.**—This is abbreviated E. H. P. and is equal to 746 watts; it is the same as the ordinary horse power, but expressed in electrical units.

**§751 Equivalents of Units.**—

1 Kilowatt = 1000 watts.
1 Kilowatt = 1.34 horse power.
1 Kilowatt = 3412 B. t. u. per hour.
1 Kilowatt = 44,257 foot-pounds per minute.
1 Horse power = 746 watts.
1 Horse power = .746 K. W.
1 Horse power = 33,000 foot-pounds per minute.
1 Horse power = 2545 B. t. u. per hour.
1 B. t. u. = 778 foot-pounds.

**§752 Alternating Current.**—The electric current as first generated in a dynamo is not a continuous one, but surges and pulsates so as to change its direction of flow alternately at regular recurring intervals just as a pulsating pump produces a regular and alternating surging in a water line. Hence, it is called an alternating current, and is abbreviated A. C.

**§753 Cycle.**—In the operation of a dynamo, the surging action of the electric current as first generated is analogous to the alternating swinging of a pendulum, in that the changes go thru regular cycles. When the current has passed from zero to a maximum in one direction, then back again thru zero and to a maximum in the alternate direction and back to zero again, it is said to have completed one cycle.

**§754 Frequency.**—The term "frequency" is used to indicate the number of cycles completed in one second. The present standard frequencies are 25 and 60.

**§755 Alternations.**—In electric currents as first generated, it takes two alternations to make one complete cycle, just as in the analogous case of the swinging pendulum. Thus a 60 cycle current makes 120 alternations per second. However, when this term is used it refers to the number of alternations per minute or 60 times those per second.

**§756 Direct Current.**—The first electric motors and electric lamps made would not work on the pulsating alternating current. In order to overcome this difficulty, a rectifying device known as a commutator was added to the dynamo and this changes the pulsating alternating current into a continuous or direct current. It is abbreviated D. C.

The commutator action is analogous to the continuous and non-pulsating water stream produced by a centrifugal pump in contradistinction to the alternating surging produced in a water line by a pulsating pump which, as before stated, is analogous to an alternating current.

**§757 Relation of Alternating and Direct Current Apparatus.**—The direct current electric motor is much more flexible and has a wider range of application than the alternating current motor. This accounts for the general use of the direct current motor on street cars. However, the commutators will not stand much over 1000 volts and few machines are built for over 600 volts; furthermore, direct current voltage transformers are not commercially feasible for high voltages. Since high voltages are necessary for long distance transmission of electricity, it is evident that direct current cannot be used for such service.

Alternating currents cannot be used in storage battery work; but, on the other hand, they will give much less trouble from electrolysis, see §440.

The advantage of alternating current over direct current lies almost wholly in the cheapness of construction, the cheapness of operation and high efficiency of the alternating current as compared with the direct current apparatus that is required for transformation.

**§758 Power in Electrical Circuit.**—In the case of direct current, the product of the volts and amperes gives the true number of watts or true power in the line.

With alternating current, on account of certain internal disturbances produced by the surging action of the constantly changing current, the product of the volts and amperes is not the true, but only the apparent, power. The true or actual power will always be less than this apparent power. If the voltage and current are measured

separately, the readings are the individual mean effective values and their product is the apparent power. If the voltage and current are measured by a wattmeter, the instrument indicates their combined effects synchronously or the true power in the line. This true power is the energy that is available for work.

**§759 Power Factor.**—The ratio of the true power to the apparent power is called the power factor of the line. Thus:

$$\text{Power factor} = \frac{\text{Watts or true Power.}}{\text{Amperes} \times \text{volts or apparent power.}}$$

The exact value of the power factor varies with the nature of the electrical load on the line, the following being typical:

| | |
|---|---|
| Incandescent lighting only, power factor..... | 95% |
| Arc lighting only, power factor..... | 80% |
| Lighting and motors only, power factor..... | 85% |
| Motors only, power factor..... | 80% |

**§760 K. V. A. Rating.**—Power factor conditions result in two methods of rating A. C. machines.

First, on the basis of true watts or power output, i. e., just what the actual or true power of the machine is. This is seldom used.

Second, on the basis of volt-amperes or kilovolt-amperes, abbreviated K. V. A. This represents the apparent power corresponding to the voltage and current conditions under which the machine is working. This is the rating generally used.

**§761 K. V. A. Rating and Plant Capacity.**—The importance of recognizing the distinction in rating methods is especially pertinent in considering Utility plant capacity. Thus applying the factors in §759, a 1000 K. V. A. generator will have an output of only 950 K. W. for incandescent lighting service, and 800 K. W. for motor and arc lighting service.

**§762 Primary Line.**—This is one that receives power from an external source.

**§763 Secondary Line.**—This is one that receives power from the primary by induction.

**§764 McCluer Device.**—"This consists of a wire suspended upon the telephone poles, and to which the wires of the telephones are connected at both ends and which serves as a return circuit in place of the earth." (24, p. 810)

**§765 Conduction in Distributing Systems.**—This is the discharge or escape of electricity into the earth from the wires or plants of one electrical Utility, by which the wires or plant of another Utility are affected." (24, p. 807)

**§766 Induction in Distributing Systems.**—"Induction is where wires of two circuits are parallel and so close to each other that, owing to the more powerful and changing currents in one wire, a current is induced upon the other wire, producing variations corresponding to those upon the stronger wire." (24, p. 808)

**§767 Second-Foot.**—This is used in hydraulics to indicate a flow of 1 cu. ft. of water per second. It is equivalent to 7.48 U. S. gal. per second.

**§768 Miner's Inch.**—This is a system of water measurement, used in the western states, where the flow is dependent on the position and width of a rectangular aperature, 2 in. high, in a plank 1¼ in. thick. The equivalent quantity varies in different localities, 1 second foot equalling 40 miner's inches in California and Arizona and 38.4 miner's inches in Colorado.

**§769 Laws of Water Flow:**

1. Friction loss is directly proportional to the length of pipe.
2. Friction loss increases as the square of the velocity.
3. Friction loss is independent of the pressure of the water.
4. Friction loss increases with the roughness of the interior of the pipe.
5. Friction loss increases as the diameter of the pipe is decreased.
6. The quantity of water carried by pipes of the same length and smoothness of surface with a given loss of pressure varies as the square roots of the fifth powers of the diameter.

**§770 What Is Water?**—Water is a definite compound of oxygen and hydrogen; usually carrying vegetable, mineral and animal matter in solution or suspension. The quantity of the latter constituents present depends upon the geological formations over which the water flows or thru which it percolates, and upon the previous use that man may have made of it.

The palatability of water depends mostly upon its absorbed gases, which are principally oxygen, nitrogen, carbon dioxide and hydrogen sulfid, the flat taste of boiled water being due to the absence of these gases.

**§771 Distinction Between Pure and Safe Water.**—Pure water is found only in the laboratory; that is, all natural waters carry some foreign substances.

Safe waters are those that are reasonably free from objectionable substances judged by the particular use that is to be made of the water.

"Pure and wholesome water is not a substance of absolute quality. Strictly speaking, pure water does not exist in nature; all natural waters contain substances in solution or in suspension; and, in proportion as they are objectionable in character, the water is impure." (74)

**§772 What Pure and Wholesome Water Means.** — Unquestionably the term "pure and wholesome water," as ordinarily used, relates to water intended to be used for drinking. Such a water must be free from all poisonous substances, as the salts of lead; it must be free from bacteria or other organisms liable to cause disease, such as the bacilli of typhoid fever or dysentery; it must also be free from bacteria of fecal origin, such as Bacilli Coli. Besides this, it must be practically clear, odorless, colorless, and reasonably free from objectionable chemical salts in solution and from microscopic organisms in suspension, and must be well aerated. (74)

**§773 Degree of Water Purity.**—"A water company is not bound to provide water that is chemically pure, but water that is ordinarily and reasonably pure." (606)

**§774 What Is Clarification of Water?**—This is the removal of either color or turbidity. A clarified water is not necessarily a safe water.

**§775 What Is Coagulation of Water?**—This consists in the addition to water of some substance which forms an inorganic precipitate in the water, the presence of which has a physical action upon the suspended matters, and allows them to be more readily removed by subsidence or filtration. (31)

**§776 What Is Complete Purification of Water?**—This is the complete and permanent removal of all traces of former impurities.

**§777 Stained or Colored Water.**—"This is one which is colored by vegetable extractives from leaves, soil, etc." (74)

**§778 Soiled or Turbid Water.**—"This is one made dirty by washings from the soil, i. e., by clay, silt, etc." (74)

**§779 Tainted Water.**—This is one which has an unpleasant odor, due to the decomposition of organic matter, as algae, §342, crenothrix, §344, or bryozoa, §345. (74)

**§780 Putrid Water.**—"This is one in which the decomposition of organic matter has reached such a degree that all the dissolved oxygen has disappeared and the water becomes offensive to sight and smell." (74)

**§781 Polluted Water.**—"This is one which has received and still holds the excreta of human being or animals, or the waste product of human industry." (74)

**§782 Infected Water.**—"This is one which actually contains pathogenic bacteria capable of producing disease." (74)

**§783 Significance of a Water Analysis.**—A water analysis is primarily a series of experiments undertaken with a view to assist the judgment in determining the potability of the supply. It is always imperative that the chemist be fully informed regarding the environment and history of the water source in order that correct deductions may be made. The chemical constituents are given in parts per million by weight. What a complete sanitary analysis includes is outlined in Fig. 46, p. 231. (77)

**§784 Color.**—This is not only valueless but may be positively misleading as a criterion of safety. Thus, bright sparkling waters may be laden with bacteria and may be veritable poison streams while waters of a dull color may be safe. The term colored water is limited to those waters containing colored vegetable matter in solution. (31)

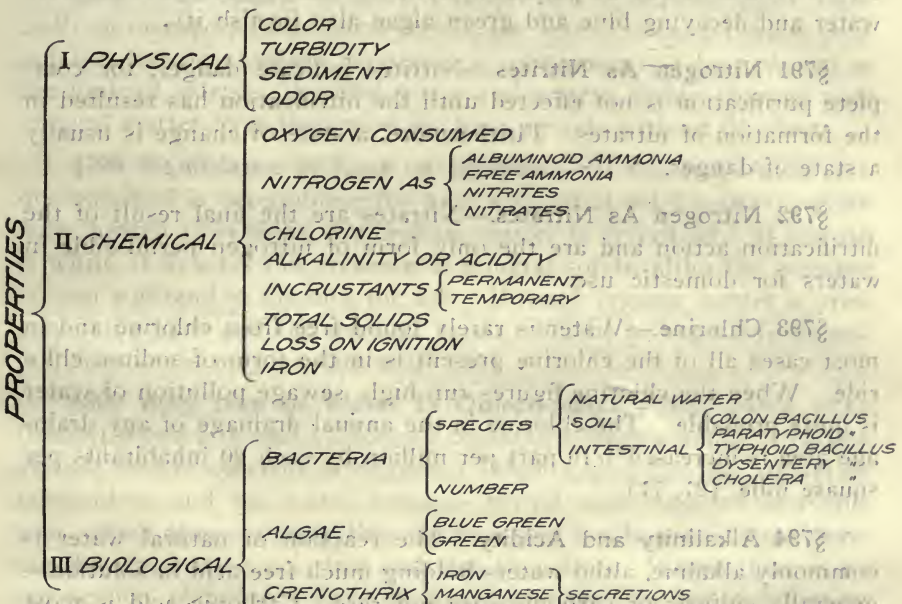
**§785 Turbidity.**—A water for a public supply should always be free from visible floating particles, and be bright and clear when viewed in bulk. Turbidity may be due to drainage contamination, growth of bacteria, clay, iron or swarms of micro-organisms. Water containing traces of iron salts in solution may be perfectly bright when first drawn, yet speedily become turbid upon standing in contact with air, on account of the formation of more highly oxidized and insoluble salts. (27)

**§786 Sediment.**—This may be sand, fragments of plants or animals or ferric oxide.

**§787 Odor.**—No water can be satisfactory as a public supply if it possesses an odor of any kind. Even when warmed and shaken no odor should be obvious. A musty odor, unmistakably different from a mouldy vegetable smell, betrays sewage contamination. (27)

**§788 Significance of Oxygen Consuming Capacity.**—The amount of oxygen consumed bears some relation to the amount of organic carbon present in water; but this relation cannot be taken as a definite one in every case. In general, it may be said that a sample which has high oxygen-consuming power will be more likely to be unwholesome than one which is low in this respect. However, the interferences are so numerous and the susceptibility to oxidation of

# FIG. 46
# WHAT A COMPLETE SANITARY WATER ANALYSIS INCLUDES



different organic matter of the same type is so different, that the method is at best only of accessory value. It is especially suitable for consecutive determinations on the same supply. (26)

**§789 Nitrogen As Albuminoid Ammonia.**—Albuminoid ammonia is that which has not been set free, but is liable to become so under further active attacks of oxygen. The sum of the free and albuminoid ammonia gives a valuable indication of what is going on in the water.

**§790 Nitrogen As Free Ammonia.**—Free ammonia is that which has been actually set free in the water, generally from a process of decay. The mere presence of free ammonia is, however, not conclusive evidence of recent pollution from human sources, because rain water and decaying blue and green algae also furnish it.

**§791 Nitrogen As Nitrites.**—Nitrites indicate danger, for complete purification is not effected until the nitrification has resulted in the formation of nitrates. Furthermore, a state of change is usually a state of danger.

**§792 Nitrogen As Nitrates.**—Nitrates are the final result of the nitrification action and are the only form of nitrogen permissible in waters for domestic use.

**§793 Chlorine.**—Water is rarely found free from chlorine and in most cases all of the chlorine present is in the form of sodium chloride. When the chlorine figures run high, sewage pollution of water is quite probable. The chlorine in the annual drainage of any drainage area is increased 1/10 part per million by each 20 inhabitants per square mile. (27, 77)

**§794 Alkalinity and Acidity.**—The reaction of natural water is commonly alkaline, altho waters holding much free acid in solution—generally sulfuric or carbonic—are not rare. Carbonic acid is most important in this connection, because its amount is usually far greater than that of any other acid present in water. Carbonic acid may also have a marked effect on the precipitation of iron in iron-waters.

Alkalinity is sometimes used synonymously for temporary hardness, and certain forms of it may produce tuberculation of water mains as shown in Fig. 28, p. 112, and discussed in §343.

**§795 Permanent Hardness.**—This is caused by the presence of calcium sulfate and other soluble salts of calcium and magnesium, not carbonates, held in solution by the solvent action of the water itself. Such water cannot be materially softened by boiling under ordinary pressure. (77)

**§796 Temporary Hardness.**—This is caused by carbonates of calcium and magnesium held in solution by carbonic acid present in the water. Boiling such a water expels the carbonic acid, whereupon the salts separate from solution. (77)

**§797 Degree of Hardness.**—"The ordinary person washing his hands considers the water soft if the soap will quickly produce suds without curdling. A hardness of 10 parts per million is practically unnoticeable, and it requires a hardness of 20 or 30 parts per million to produce curdling. When the hardness rises above 50 the water is well entitled to the appellation 'hard', and above 100 it may be called 'very hard.'" (74)

**§798 Total Solids.**—Excessive proportion of mineral solids, especially of marked physiological action, are known to render water non-potable, but no absolute maximum or minimum can be assigned as the limit of safety. Distilled water and waters highly charged with mineral matter have been used for long periods without ill effects.

**§799 Significance of Loss on Ignition.**—"If the evaporated residue obtained in determining the total amount of solid matter is gradually heated to redness, the organic matter is driven off. If the ash is white, it denotes the presence of mineral solids, altho the presence of iron will tend to discolor the ash. If much organic matter is present, it blackens and the peculiar smell inherent to vegetable or animal substances may be detected." (55)

**§800 Why Iron in Water Is Objectionable.**—Iron water when freshly drawn is usually colorless, contains a large amount of carbon dioxide and is deficient in oxygen. When exposed to air, oxidation takes place and the water becomes turbid with oxidized insoluble iron, which after a time gathers in flocs and finally precipitates, leaving the water itself colorless and free from iron. Where there is no purification plant, this precipitation takes place in the distributing system. Tea made with the water is black. Rust spots appear on linen—the so-called iron-mold being due to the deposition of iron oxide within the fibres of the material affected. Plumbing fixtures are stained with iron rust. After a sudden disturbance, as after a large fire, the water is exceedingly turbid with precipitated iron oxide.

The so-called iron bacteria, of which the crenothrix growths—see §344—are typical, may in some cases grow and feed upon the organic matter and cause a precipitation of iron. (27, 31, 107)

**§801 Percentage of Iron That Will Give Trouble.**—Three-hundredths of a part in 100 of metallic iron very rarely precipitates or causes any trouble. Five-hundredths occasionally precipitates, and this amount may be taken as the allowable limit of iron in a satis-

factory water. One-tenth of a part is sure to precipitate and give rise to serious complaint, while two- or three-tenths of a part in 1000 makes the water entirely unsuitable for domestic purposes. (31)

**§802 What Are Bacteria?**—"Bacteria are the smallest of known organisms, the breadth of an average bacillus being about 1/25,000 of an inch. The different forms which bacteria are known to assume may all be reduced to three types:

1. Coccus, or round bacteria.
2. Bacillus, or rod bacteria.
3. Spirillum, or spiral bacteria.

These shapes are constant; that is, a coccus species always retains its spherical form, and the same can be said of the bacillus and spirillum. In the case of the bacillus group, however, it often happens that the rods are so small that they appear almost like cocci." (6)

**§803 Distinction Between Bacteria, Germs and Microbes.**—The terms germ, microbe and microorganism include the smallest organisms of the animal kingdom, and are often erroneously used synonomously with bacteria. (9)

**§804 Bacteria Belong to the Vegetable, and Not to the Animal Kingdom.**—The most common mistake that is made concerning bacteria is that they are all minute animals. This is a mistake due, probably, to the fact that people find it difficult to associate with the plant life they are familiar with, organisms which are free and motil, characteristics commonly supposed to be monopolies of the animal kingdom. With regard to bacteria, their characteristics proclaim them to be members of the vegetable kingdom. (6)

**§805 Classes of Bacteria Found in Water.**—"Water always contains bacteria, many of which are perfectly harmless as far as man is concerned, and exist in the water composing a natural flora. None of the bacteria found normally in water is harmful to man. Some of these, however, may cause trouble by growing in the water pipes, filling them up, as in the case of the crenothrix." (10)

The bacteria found in water may be classified as shown in Fig. 46, p. 231.

**§806 Natural Water Bacteria.**—"These are generally regarded as harmless to man. They are frequently numerous in river, lake, and all surface waters; certain species predominate at one season, and disappear at another." (46)

**§807 Soil Bacteria From Surface Washings.**—"During times of flood, high water, and after rains, numerous soil organisms are found in natural waters and occasionally certain species persist for a considerable time." (46)

**§808 Colon Bacillus.**—This is also known under the names of B. Coli, B. Coli communis, and B. Coli verus. It is a constant inhabitant of the intestinal canal of human beings and animals, and is practically ubiquitous in all neighborhoods which are thickly populated. It is not dangerous or injurious in itself, but is valuable as an indicator of contamination from human or animal sources.

It must also be remembered that the finding of a few colon bacilli in water does not necessarily have any special significance, since the number found, rather than mere presence, should be used as a criterion of recent sewage pollution. The absence of the colon bacillus demonstrates the harmlessness of a water as far as bacteriology can prove it. (7)

**§809 Paratyphoid Bacillus.**—This is an attypical organism that produces a typhoid-like disease in man. Many isolated cases of paratyphoid infection have been observed, and in some cases the clinical symptoms of the disease are substantially identical with typhoid fever, but many cases show a tendency to run a mild course. Some cases of paratyphoid infection are accompanied with severe diarrhea and might be mistaken clinically for Asiatic cholera. (5)

"The fact that both typhoid and paratyphoid fever may be caused by polluted water, and that cases may exist side by side in the same epidemic undifferentiated, suggests that the full extent of water-infection may not now be recognized." (5)

**§810 Typhoid Bacillus.**—"This is the cause of typhoid fever. These bacilli are present in the body of every typhoid patient and large numbers are cast off in a living and virulent condition thru the patient's feces and urine. Unfortunately, they do not die immediately upon leaving the body, but maintain a vagabond existence in various places and for various lengths of time, ultimately perishing of exposure or starvation unless they find a temporary home in the intestines of a new human host." (70)

"The most favorable temperature is that of the human body; above 122° F. no growth occurs. Boiling will kill the bacilli immediately." (70)

Freezing has an important influence on their longevity but is not necessarily fatal. In the infamous Plymouth, Pa., epidemic, the bacilli lived in frozen fecal matter for many weeks. (70)

This bacillus is very difficult to isolate, and hence is not separately determined in the ordinary bacteriological examination. (70)

**§811 Dysentery Bacillus.**—There are several bacilli that are the cause of dysentery and various other diarrheal diseases. They closely resemble the typhoid bacillus and in most instances are produced by the same general sources of contamination. The elimination of the typhoid bacillus usually results in the elimination of the dysentery bacilli. (7)

**§812 Asiatic Cholera Bacillus.**—This is the cause of the deadly Asiatic cholera, and is also known as Spirillum cholera and Comma bacillus.

It grows easily at 75° F., but is killed at 140° F. When frozen in ice it may live for several days. In impure water, moist linen and food stuffs it may live for many days.

"The bacillus leaves the body of the infected subject with the feces only. Infection takes place, so far as we know, only by way of the mouth. From these two facts it follows that the chief source of danger for a community lies in infection of the water supply. It has been statistically noted, by Koch, that cholera in its spread not infrequently follows the water courses. The sudden appearance of cholera in a place far distant from the prevalent epidemic may be explained by the occasional presence of cholera spirilla in the dejecta of convalescents as late as two or three weeks after apparent recovery from the disease and consequent release from quarantine." (7)

"In one test with the water supply of Berlin, the bacillus retained its vitality for 267 days, and in another for 382 days, notwithstanding the fact that many other organisms were present at the same time." (8)

**§813 Water as Bacteria Carrier.**—Carriage by water, thru public supplies, is one of the most important modes of transmission of typhoid, paratyphoid, cholera and dysentery bacilli. The feces of a single patient may pollute an entire water supply and cause a deadly epidemic.

**§814 Number Bacteria Present.**—"The value of the quantitative estimation of bacteria in water is only a comparative one, and no arbitrary standards can be established for the purity of water on this basis. In general, it may be said that water containing 100 bacteria to the cubic centimeter or less, is apt to be comparatively pure; that water containing 500 bacteria to the cubic centimeter, or over, is open to suspicion, and any water containing over 1000 bacteria to the cubic centimeter is probably from a polluted source. At the same time it is quite impossible to draw any direct conclusions from numerical colony counts, and all such results must be carefully weighed in the balance with qualitative analyses, chemical tests and knowledge of environmental conditions." (7)

Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it.

—Dr. Johnson.

# Chapter 15

## REFERENCE DATA.

## TABLE 1.

## PRESENT WORTHS.

**Present value of $1.00 per annum due in any number of years, from 1 to 50, inclusive.**

| Years. | 3% | 3½% | 4% | 4½% | 5% | 6% |
|---|---|---|---|---|---|---|
| 1 | 0.9709 | 0.9662 | 0.9615 | 0.9569 | 0.9524 | 0.9434 |
| 2 | 1.9135 | 1.8997 | 1.8861 | 1.8727 | 1.8594 | 1.8334 |
| 3 | 2.8286 | 2.8016 | 2.7751 | 2.7490 | 2.7232 | 2.6730 |
| 4 | 3.7171 | 3.6731 | 3.6299 | 3.5875 | 3.5460 | 3.4651 |
| 5 | 4.5797 | 4.5151 | 4.4518 | 4.3900 | 4.3295 | 4.2124 |
| 6 | 5.4172 | 5.3286 | 5.2421 | 5.1579 | 5.0757 | 4.9173 |
| 7 | 6.2303 | 6.1145 | 6.0021 | 5.8927 | 5.7864 | 5.5824 |
| 8 | 7.0197 | 6.8740 | 6.7327 | 6.5959 | 6.4632 | 6.2098 |
| 9 | 7.7861 | 7.6077 | 7.4353 | 7.2688 | 7.1078 | 6.8017 |
| 10 | 8.5302 | 8.3166 | 8.1109 | 7.9127 | 7.7217 | 7.3601 |
| 11 | 9.2526 | 9.0016 | 8.7605 | 8.5289 | 8.3064 | 7.8869 |
| 12 | 9.9540 | 9.6633 | 9.3851 | 9.1186 | 8.8633 | 8.3838 |
| 13 | 10.6350 | 10.3027 | 9.9856 | 9.6829 | 9.3936 | 8.8527 |
| 14 | 11.2961 | 10.9205 | 10.5631 | 10.2228 | 9.8986 | 9.2950 |
| 15 | 11.9379 | 11.5174 | 11.1184 | 10.7395 | 10.3797 | 9.7122 |
| 16 | 12.5611 | 12.0941 | 11.6523 | 11.2340 | 10.8378 | 10.1050 |
| 17 | 13.1661 | 12.6513 | 12.1657 | 11.7072 | 11.2741 | 10.4773 |
| 18 | 13.7535 | 13.1897 | 12.6593 | 12.1600 | 11.6896 | 10.8276 |
| 19 | 14.3238 | 13.7098 | 13.1339 | 12.5933 | 12.0853 | 11.1501 |
| 20 | 14.8775 | 14.2124 | 13.3503 | 13.0079 | 12.4622 | 11.4699 |
| 21 | 15.4150 | 14.6980 | 14.0292 | 13.4047 | 12.8212 | 11.7641 |
| 22 | 15.9369 | 15.1671 | 14.4511 | 13.7844 | 13.6030 | 12.0416 |
| 23 | 16.4436 | 15.6204 | 14.8568 | 14.1478 | 13.4886 | 12.3034 |
| 24 | 16.9355 | 16.0584 | 15.2470 | 14.4955 | 13.7986 | 12.5504 |
| 25 | 17.4131 | 16.4815 | 15.6221 | 14.8282 | 14.0939 | 12.7834 |
| 26 | 17.8768 | 16.8904 | 15.9828 | 15.1466 | 14.3752 | 13.0032 |
| 27 | 18.3270 | 17.2854 | 16.3296 | 15.4513 | 14.6430 | 13.2105 |
| 28 | 18.7641 | 17.6670 | 16.6631 | 15.7419 | 14.8981 | 13.4062 |
| 29 | 19.1885 | 18.0358 | 16.9837 | 16.0219 | 15.1411 | 13.5907 |
| 30 | 19.6004 | 18.3920 | 17.2920 | 16.2889 | 15.3725 | 13.7648 |
| 31 | 20.0004 | 18.7363 | 17.5885 | 16.5444 | 15.5928 | 13.9291 |
| 32 | 20.3888 | 19.0689 | 17.8736 | 16.7889 | 15.8027 | 14.0840 |
| 33 | 20.7658 | 19.3902 | 18.1476 | 17.0229 | 16.0025 | 14.2302 |
| 34 | 21.1318 | 19.7007 | 18.4112 | 17.2468 | 16.1929 | 14.3681 |
| 35 | 21.4872 | 20.0007 | 18.6646 | 17.4610 | 16.3742 | 14.4982 |
| 36 | 21.8323 | 20.2905 | 18.9083 | 17.6660 | 16.5469 | 14.6210 |
| 37 | 22.1672 | 20.5705 | 19.1426 | 17.8622 | 16.7113 | 14.7368 |
| 38 | 22.4925 | 20.8411 | 19.3679 | 18.0500 | 16.8679 | 14.8460 |
| 39 | 22.8092 | 21.1025 | 19.5845 | 18.2297 | 17.0170 | 14.9491 |
| 40 | 23.1148 | 21.3551 | 19.7928 | 18.4016 | 17.1591 | 15.0463 |
| 41 | 23.4124 | 21.5991 | 19.9931 | 18.5661 | 17.2944 | 15.1380 |
| 42 | 23.7014 | 21.8349 | 20.1856 | 18.7235 | 17.4232 | 15.2245 |
| 43 | 23,9819 | 22.0627 | 20.3708 | 18.8742 | 17.5459 | 15.3062 |
| 44 | 24.2543 | 22.2828 | 20.5488 | 19.0184 | 17.6628 | 15.3832 |
| 45 | 24.5187 | 22.4955 | 20.7200 | 19.1563 | 17.7741 | 15.4558 |
| 46 | 24.7754 | 22.7009 | 20.8847 | 19.2884 | 17.8801 | 15.5244 |
| 47 | 25.0247 | 22.8994 | 21.0429 | 19.4147 | 17.9801 | 15.5890 |
| 48 | 25.2667 | 23.0912 | 21.1951 | 19.5356 | 18.0772 | 15.6500 |
| 49 | 25.5017 | 23.2766 | 21.3415 | 19.6513 | 18.1687 | 15.7076 |
| 50 | 25,7298 | 23.4556 | 21.4852 | 19.7620 | 18.2559 | 15.7619 |

## TABLE 2.

### FUTURE WORTHS—AT END OF VARIOUS YEARS—
**Of Uniform Series of Payments of $1.00 Each, Made at Beginning of Every 6 Months.**

| A | B | Principal and Interest Compounded Semi-Annually, at Following Interest Rates Per Annum. | | | |
|---|---|---|---|---|---|
| Years. | Principal only. | C 2% | D 3% | E 4% | F 5% |
| 1 | $ 2. | 2.03010 | 2.04523 | 2.06040 | 2.07563 |
| 2 | 4. | 4.10101 | 4.15227 | 4.20404 | 4.25633 |
| 3 | 6. | 6.21354 | 6.32299 | 6.43428 | 6.54743 |
| 4 | 8. | 8.36853 | 8.55933 | 8.75463 | 8.95452 |
| 5 | 10. | 10.56683 | 10.86236 | 11.16872 | 11.48347 |
| 6 | 12. | 12.80933 | 13.23683 | 13.68033 | 14.14044 |
| 7 | 14. | 15.09690 | 15.68214 | 16.29342 | 16.93193 |
| 8 | 16. | 17.43044 | 18.20136 | 19.01207 | 19.86473 |
| 9 | 18. | 19.81090 | 20.79672 | 21.84056 | 22.94601 |
| 10 | 20. | 22.23919 | 23.47052 | 24.78332 | 26.18327 |
| 11 | 22. | 24.71630 | 26.22514 | 27.84496 | 29.58443 |
| 12 | 24. | 27.24320 | 29.06302 | 31.03030 | 33.15776 |
| 13 | 26. | 29.82089 | 31.98668 | 34.34432 | 36.91200 |
| 14 | 28. | 32.45039 | 34.99870 | 37.79223 | 40.85630 |
| 15 | 30. | 35.13274 | 38.10176 | 41.37944 | 45.00027 |
| 16 | 32. | 37.86901 | 41.29861 | 45.11157 | 49.35403 |
| 17 | 34. | 40.66028 | 44.59209 | 48.99448 | 53.92821 |
| 18 | 36. | 43.50765 | 47.98511 | 53.03425 | 58.73395 |
| 19 | 38. | 46.41225 | 51.48068 | 57.23724 | 63.78298 |
| 20 | 40. | 49.37524 | 55.08191 | 61.61002 | 69.08762 |
| 21 | 42. | 52.39778 | 58.79199 | 66.15947 | 74.66080 |
| 22 | 44. | 55.48107 | 62.61420 | 70.89271 | 80.51613 |
| 23 | 46. | 58.62634 | 66.55194 | 75.81718 | 86.66789 |
| 24 | 48. | 61.83483 | 70.60870 | 80.94059 | 93.13107 |
| 25 | 50. | 65.10781 | 74.78807 | 86.27099 | 99.92146 |
| 26 | 52. | 68.44658 | 79.09376 | 91.81674 | 107.05561 |
| 27 | 54. | 71.85246 | 83.52960 | 97.58653 | 114.55092 |
| 28 | 56. | 75.32679 | 88.09951 | 103.58943 | 122.42569 |
| 29 | 58. | 78.87096 | 92.80754 | 109.83484 | 130.69911 |
| 30 | 60. | 82.48637 | 97.65787 | 116. 33257 | 139.39138 |
| 31 | 62. | 86.17444 | 102.65481 | 123.09281 | 148.52369 |
| 32 | 64. | 89.93665 | 107.80277 | 130.12616 | 158.11833 |
| 33 | 66. | 93.77448 | 113.10634 | 137.44365 | 168.19870 |
| 34 | 68. | 97.68944 | 118.57020 | 145.05678 | 178.78938 |
| 35 | 70. | 101.68310 | 124.19921 | 152.97747 | 189.91622 |
| 36 | 72. | 105.75703 | 129.99836 | 161.21816 | 201.60635 |
| 37 | 74. | 109.91285 | 135.97278 | 169.79177 | 213.88830 |
| 38 | 76. | 114.15220 | 142.12778 | 178.71176 | 226.79202 |
| 39 | 78. | 118.47675 | 148.46882 | 187.99212 | 240.34899 |
| 40 | 80. | 122.88824 | 155.00152 | 197.64740 | 254.59228 |

## TABLE 3.

## COMPOUND INTEREST TABLE.

**Value of $1.00 (100 per cent.) at End of Any Year, From 1 to 40, Interest Compounded Annually.**

| Years. | 1% | 2% | 3% | 4% | 5% | 6% |
|---|---|---|---|---|---|---|
| 1 | 1.0100 | 1.0200 | 1.0300 | 1.0400 | 1.0500 | 1.0600 |
| 2 | 1.0201 | 1.0404 | 1.0609 | 1.0816 | 1.1025 | 1.1236 |
| 3 | 1.0303 | 1.0612 | 1.0927 | 1.1249 | 1.1576 | 1.1910 |
| 4 | 1.0406 | 1.0824 | 1.1255 | 1.1699 | 1.2155 | 1.2625 |
| 5 | 1.0510 | 1.1041 | 1.1593 | 1.2167 | 1.2763 | 1.3382 |
| 6 | 1.0615 | 1.1262 | 1.1941 | 1.2653 | 1.3401 | 1.4185 |
| 7 | 1.0721 | 1.1487 | 1.2299 | 1.3159 | 1.4071 | 1.5036 |
| 8 | 1.0829 | 1.1717 | 1.2668 | 1.3686 | 1.4775 | 1.5938 |
| 9 | 1.0937 | 1.1951 | 1.3048 | 1.4233 | 1.5513 | 1.6895 |
| 10 | 1.1046 | 1.2190 | 1.3439 | 1.4802 | 1.6289 | 1.7908 |
| 11 | 1.1157 | 1.2434 | 1.3842 | 1.5395 | 1.7103 | 1.8983 |
| 12 | 1.1268 | 1.2682 | 1.4258 | 1.6010 | 1.7959 | 2.0122 |
| 13 | 1.1381 | 1.2936 | 1.4685 | 1.6651 | 1.8856 | 2.1329 |
| 14 | 1.1495 | 1.3195 | 1.5126 | 1.7317 | 1.9799 | 2.2609 |
| 15 | 1.1610 | 1.3459 | 1.5580 | 1.8009 | 2.0789 | 2.3966 |
| 16 | 1.1726 | 1.3728 | 1.6047 | 1.8730 | 2.1829 | 2.5404 |
| 17 | 1.1843 | 1.4002 | 1.6528 | 1.9479 | 2.2920 | 2.6928 |
| 18 | 1.1961 | 1.4282 | 1.7024 | 2.0258 | 2.4066 | 2.8543 |
| 19 | 1.2081 | 1.4568 | 1.7535 | 2.1068 | 2.5270 | 3.0256 |
| 20 | 1.2202 | 1.4859 | 1.8061 | 2.1911 | 2.6533 | 3.2071 |
| 21 | 1.2324 | 1.5157 | 1.8603 | 2.2788 | 2.7860 | 3.3996 |
| 22 | 1.2447 | 1.5460 | 1.9161 | 2.3699 | 2.9253 | 3.6035 |
| 23 | 1.2572 | 1.5769 | 1.9736 | 2.4647 | 3.0715 | 3.8197 |
| 24 | 1.2697 | 1.6084 | 2.0328 | 2.5633 | 3.2251 | 4.0489 |
| 25 | 1.2824 | 1.6406 | 2.0938 | 2.6658 | 3.3864 | 4.2919 |
| 26 | 1.2953 | 1.6734 | 2.1566 | 2.7725 | 3.5557 | 4.5494 |
| 27 | 1.3082 | 1.7069 | 2.2213 | 2.8834 | 3.7335 | 4.8223 |
| 28 | 1.3213 | 1.7410 | 2.2879 | 2.9987 | 3.9201 | 5.1117 |
| 29 | 1.3345 | 1.7758 | 2.3566 | 3.1187 | 4.1161 | 5.4184 |
| 30 | 1.3478 | 1.8114 | 2.4273 | 3.2434 | 4.3219 | 5.7435 |
| 31 | 1.3613 | 1.8476 | 2.5001 | 3.3731 | 4.5380 | 6.0881 |
| 32 | 1.3749 | 1.8845 | 2.5751 | 3.5081 | 4.7649 | 6.4534 |
| 33 | 1.3887 | 1.9222 | 2.6523 | 3.6484 | 5.0032 | 6.8406 |
| 34 | 1.4026 | 1.9607 | 2.7319 | 3.7943 | 5.2533 | 7.2510 |
| 35 | 1.4166 | 1.9999 | 2.8139 | 3.9461 | 5.5160 | 7.6861 |
| 36 | 1.4308 | 2.0399 | 2.8983 | 4.1039 | 5.7918 | 8.1473 |
| 37 | 1.4451 | 2.0807 | 2.9852 | 4.2681 | 6.0814 | 8.6361 |
| 38 | 1.4595 | 2.1223 | 3.0748 | 4.4388 | 6.3855 | 9.1543 |
| 39 | 1.4741 | 2.1647 | 3.1670 | 4.6164 | 6.7048 | 9.7035 |
| 40 | 1.4889 | 2.2080 | 3.2620 | 4.8010 | 7.0400 | 10.2857 |

## TABLE 4.

## SEMI-ANNUAL BASIS SINKING FUND.

**Amount to be invested at beginning of every half year at following annual interest rates, compounded semi-annually, to redeem $100.00 (100 per cent.) at end of any year from 1 to 50.**

| Years. | 2½% | 3% | 3% | 4% | 4½% | 5% |
|---|---|---|---|---|---|---|
| 1 | 49.076 | 48.894 | 48.714 | 48.534 | 48.356 | 48.178 |
| 2 | 24.233 | 24.083 | 23.934 | 23.787 | 23.640 | 23.494 |
| 3 | 15.954 | 15.815 | 15.678 | 15.542 | 15.407 | 15.273 |
| 4 | 11.816 | 11.683 | 11.552 | 11.423 | 11.294 | 11.168 |
| 5 | 9.334 | 9.205 | 9.079 | 8.954 | 8.830 | 8.708 |
| 6 | 7.680 | 7.555 | 7.431 | 7.310 | 7.190 | 7.072 |
| 7 | 6.499 | 6.377 | 6.256 | 6.137 | 6.021 | 5.906 |
| 8 | 5.614 | 5.494 | 5.376 | 5.260 | 5.146 | 5.034 |
| 9 | 4.927 | 4.809 | 4.692 | 4.579 | 4.467 | 4.358 |
| 10 | 4.377 | 4.261 | 4.147 | 4.035 | 3.926 | 3.819 |
| 11 | 3.928 | 3.813 | 3.701 | 3.591 | 3.484 | 3.380 |
| 12 | 3.554 | 3.441 | 3.330 | 3.223 | 3.118 | 3.016 |
| 13 | 3.238 | 3.126 | 3.018 | 2.912 | 2.809 | 2.709 |
| 14 | 2.968 | 2.857 | 2.750 | 2.646 | 2.545 | 2.448 |
| 15 | 2.744 | 2.625 | 2.519 | 2.417 | 2.318 | 2.222 |
| 16 | 2.529 | 2.421 | 2.317 | 2.217 | 2.120 | 2.026 |
| 17 | 2.349 | 2.243 | 2.140 | 2.041 | 1.946 | 1.854 |
| 18 | 2.189 | 2.084 | 1.983 | 1.886 | 1.792 | 1.703 |
| 19 | 2.046 | 1.943 | 1.843 | 1.747 | 1.656 | 1.568 |
| 20 | 1.918 | 1.816 | 1.717 | 1.623 | 1.533 | 1.447 |
| 21 | 1.802 | 1.701 | 1.604 | 1.512 | 1.423 | 1.339 |
| 22 | 1.697 | 1.597 | 1.502 | 1.411 | 1.324 | 1.242 |
| 23 | 1.602 | 1.503 | 1.408 | 1.319 | 1.234 | 1.154 |
| 24 | 1.514 | 1.416 | 1.323 | 1.236 | 1.152 | 1.074 |
| 25 | 1.434 | 1.337 | 1.246 | 1.159 | 1.078 | 1.000 |
| 26 | 1.360 | 1.264 | 1.174 | 1.089 | 1.009 | .934 |
| 27 | 1.291 | 1.197 | 1.108 | 1.025 | .946 | .873 |
| 28 | 1.228 | 1.135 | 1.048 | .965 | .889 | .817 |
| 29 | 1.170 | 1.078 | .991 | .911 | .835 | .765 |
| 30 | 1.115 | 1.024 | .939 | .860 | .786 | .717 |
| 31 | 1.064 | .974 | .890 | .812 | .740 | .673 |
| 32 | 1.016 | .928 | .845 | .769 | .698 | .632 |
| 33 | .972 | .884 | .803 | .728 | .659 | .595 |
| 34 | .930 | .843 | .763 | .689 | .622 | .559 |
| 35 | .891 | .805 | .726 | .654 | .587 | .527 |
| 36 | .854 | .769 | .692 | .620 | .555 | .496 |
| 37 | .819 | .735 | .659 | .589 | .525 | .468 |
| 38 | .786 | .704 | .628 | .560 | .497 | .441 |
| 39 | .755 | .674 | .599 | .532 | .471 | .416 |
| 40 | .726 | .645 | .572 | .506 | .446 | .393 |
| 41 | .698 | .618 | .546 | .482 | .423 | .371 |
| 42 | .671 | .593 | .522 | .458 | .401 | .351 |
| 43 | .646 | .569 | .499 | .437 | .381 | .331 |
| 44 | .622 | .546 | .477 | .416 | .362 | .313 |
| 45 | .600 | .524 | .457 | .397 | .343 | .296 |
| 46 | .578 | .504 | .437 | .378 | .326 | .281 |
| 47 | .557 | .484 | .419 | .361 | .310 | .266 |
| 48 | .538 | .465 | .401 | .344 | .295 | .251 |
| 49 | .519 | .448 | .384 | .329 | .280 | .238 |
| 50 | .501 | .431 | .368 | .314 | .267 | .226 |

## TABLE 5.
## ANNUAL BASIS SINKING FUND OR ANNUITY TABLE.

Amount to be invested at END of every year, at following annual interest rates, compounded annually, to redeem $100 (100%) at end of any year from 1 to 50.

| Years | 2½% | 3% | 3½% | 4% | 4½% | 5% |
|---|---|---|---|---|---|---|
| 1 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| 2 | 49.38 | 49.26 | 49.14 | 49.02 | 48.90 | 48.78 |
| 3 | 32.51 | 32.36 | 32.19 | 32.03 | 31.88 | 31.72 |
| 4 | 24.08 | 23.90 | 23.73 | 23.55 | 23.37 | 23.20 |
| 5 | 19.02 | 18.84 | 18.65 | 18.46 | 18.28 | 18.10 |
| 6 | 15.65 | 15.46 | 15.27 | 15.08 | 14.89 | 14.70 |
| 7 | 13.25 | 13.05 | 12.85 | 12.66 | 12.47 | 12.28 |
| 8 | 11.45 | 11.25 | 11.05 | 10.85 | 10.66 | 10.47 |
| 9 | 10.05 | 9.84 | 9.64 | 9.45 | 9.26 | 9.07 |
| 10 | 8.93 | 8.72 | 8.52 | 8.33 | 8.14 | 7.95 |
| 11 | 8.01 | 7.81 | 7.61 | 7.42 | 7.23 | 7.04 |
| 12 | 7.25 | 7.05 | 6.85 | 6.66 | 6.47 | 6.28 |
| 13 | 6.60 | 6.40 | 6.21 | 6.01 | 5.83 | 5.65 |
| 14 | 6.05 | 5.85 | 5.66 | 5.47 | 5.28 | 5.10 |
| 15 | 5.58 | 5.38 | 5.18 | 4.99 | 4.81 | 4.63 |
| 16 | 5.16 | 4.96 | 4.77 | 4.58 | 4.40 | 4.23 |
| 17 | 4.79 | 4.60 | 4.40 | 4.22 | 4.04 | 3.87 |
| 18 | 4.47 | 4.27 | 4.08 | 3.90 | 3.72 | 3.55 |
| 19 | 4.18 | 3.98 | 3.79 | 3.61 | 3.44 | 3.27 |
| 20 | 3.91 | 3.72 | 3.54 | 3.36 | 3.19 | 3.02 |
| 21 | 3.68 | 3.49 | 3.30 | 3.13 | 2.96 | 2.80 |
| 22 | 3.46 | 3.27 | 3.09 | 2.92 | 2.75 | 2.60 |
| 23 | 3.27 | 3.08 | 2.90 | 2.73 | 2.57 | 2.41 |
| 24 | 3.09 | 2.90 | 2.73 | 2.56 | 2.40 | 2.25 |
| 25 | 2.93 | 2.74 | 2.57 | 2.40 | 2.24 | 2.10 |
| 26 | 2.78 | 2.59 | 2.42 | 2.26 | 2.10 | 1.96 |
| 27 | 2.64 | 2.46 | 2.29 | 2.12 | 1.97 | 1.83 |
| 28 | 2.51 | 2.33 | 2.16 | 2.00 | 1.85 | 1.71 |
| 29 | 2.39 | 2.21 | 2.04 | 1.89 | 1.74 | 1.60 |
| 30 | 2.28 | 2.10 | 1.94 | 1.78 | 1.64 | 1.51 |
| 31 | 2.17 | 2.00 | 1.84 | 1.69 | 1.54 | 1.41 |
| 32 | 2.08 | 1.90 | 1.74 | 1.60 | 1.46 | 1.33 |
| 33 | 1.99 | 1.82 | 1.66 | 1.51 | 1.37 | 1.25 |
| 34 | 1.90 | 1.73 | 1.58 | 1.43 | 1.30 | 1.18 |
| 35 | 1.82 | 1.65 | 1.50 | 1.36 | 1.23 | 1.11 |
| 36 | 1.75 | 1.58 | 1.43 | 1.29 | 1.16 | 1.04 |
| 37 | 1.67 | 1.51 | 1.36 | 1.22 | 1.10 | .98 |
| 38 | 1.61 | 1.45 | 1.30 | 1.16 | 1.04 | .93 |
| 39 | 1.54 | 1.38 | 1.24 | 1.11 | .99 | .88 |
| 40 | 1.48 | 1.33 | 1.18 | 1.05 | .93 | .83 |
| 41 | 1.43 | 1.27 | 1.13 | 1.00 | .89 | .78 |
| 42 | 1.37 | 1.22 | 1.08 | .95 | .84 | .74 |
| 43 | 1.32 | 1.17 | 1.03 | .91 | .80 | .70 |
| 44 | 1.27 | 1.12 | .99 | .87 | .76 | .66 |
| 45 | 1.23 | 1.08 | .95 | .83 | .72 | .63 |
| 46 | 1.18 | 1.04 | .91 | .79 | .68 | .59 |
| 47 | 1.14 | 1.00 | .87 | .75 | .65 | .56 |
| 48 | 1.10 | .96 | .83 | .72 | .62 | .53 |
| 49 | 1.06 | .92 | .80 | .69 | .59 | .50 |
| 50 | 1.03 | .89 | .76 | .66 | .56 | .48 |

## TABLE 6.

## SEMI-ANNUAL INSTALLMENT PAYMENT TABLE.

Semi-annual payments at end of each six months, of each year, which will at date of last payment, pay a debt of $100 (100%) now due, and its interest at the following annual interest rates.

| Time in Years | 2% | 3% | 4% | 5% | 6% | 7% |
|---|---|---|---|---|---|---|
| 1 | 50.75 | 51.12 | 51.50 | 51.88 | 52.26 | 52.64 |
| 2 | 25.62 | 25.94 | 26.26 | 26.58 | 26.90 | 27.22 |
| 3 | 17.25 | 17.55 | 17.85 | 18.15 | 18.46 | 18.76 |
| 4 | 13.06 | 13.35 | 13.65 | 13.94 | 14.24 | 14.54 |
| 5 | 10.55 | 10.84 | 11.13 | 11.42 | 11.72 | 12.02 |
| 6 | 8.88 | 9.16 | 9.45 | 9.74 | 10.04 | 10.34 |
| 7 | 7.69 | 7.97 | 8.26 | 8.55 | 8.85 | 9.15 |
| 8 | 6.79 | 7.07 | 7.36 | 7.66 | 7.96 | 8.26 |
| 9 | 6.09 | 6.38 | 6.67 | 6.96 | 7.27 | 7.58 |
| 10 | 5.54 | 5.82 | 6.11 | 6.41 | 6.72 | 7.03 |
| 11 | 5.08 | 5.37 | 5.66 | 5.96 | 6.27 | 6.59 |
| 12 | 4.70 | 4.99 | 5.28 | 5.59 | 5.90 | 6.22 |
| 13 | 4.38 | 4.67 | 4.97 | 5.27 | 5.59 | 5.92 |
| 14 | 4.11 | 4.40 | 4.69 | 5.00 | 5.32 | 5.66 |
| 15 | 3.87 | 4.16 | 4.46 | 4.77 | 5.10 | 5.43 |
| 16 | 3.66 | 3.95 | 4.26 | 4.57 | 4.90 | 5.24 |
| 17 | 3.48 | 3.77 | 4.08 | 4.40 | 4.73 | 5.07 |
| 18 | 3.32 | 3.61 | 3.92 | 4.24 | 4.58 | 4.92 |
| 19 | 3.17 | 3.47 | 3.78 | 4.10 | 4.44 | 4.79 |
| 20 | 3.04 | 3.34 | 3.65 | 3.98 | 4.32 | 4.68 |
| 21 | 2.92 | 3.22 | 3.54 | 3.87 | 4.21 | 4.58 |
| 22 | 2.82 | 3.12 | 3.43 | 3.76 | 4.12 | 4.48 |
| 23 | 2.72 | 3.02 | 3.34 | 3.68 | 4.03 | 4.40 |
| 24 | 2.63 | 2.93 | 3.26 | 3.60 | 3.95 | 4.33 |
| 25 | 2.55 | 2.85 | 3.18 | 3.52 | 3.88 | 4.26 |

## TABLE 7.

## METCALF'S USEFUL LIFE TABLE.

| | Useful life in years. |
|---|---|
| Reservoirs | 50-100* |
| Standpipes | 25- 40 |
| Masonry buildings | 40- 50 |
| Wooden buildings | 20- 50 |
| Cast iron pipe, large diameter | 50- 75 |
| Cast iron pipe, small diameter | 20- 40 |
| Steel pipe | 25- 50 |
| Wood stave pipe | 20- 30 |
| Wrot iron service pipe | 15- 30 |
| Meters | 20- 30 |
| Hydrants | 40- 50 |
| Gates | 40- 50 |
| Pumping and auxiliary machinery | 20- 30 |
| Steam engines | 15- 25 |
| Boilers | 12- 16 |

*Except when subject is silt.

## TABLE 8.

## APPROVED DEPRECIATION RATES.

**Compiled by Henry Floy, (97.)** **Maintenance not included.**

A. Arbitrators. Atlanta. Ga., Street Lighting Controversy.
B. New York Public Service Commission. 1st District.
C. St. Louis Public Service Commission. St. Louis, Mo.
D. Chicago Traction Valuation Commission, Con. Traction Co.
E. Wisconsin Railroad Commission.

| Property. | Depreciation Per cent. per year. Straight line. | Key to Authority. |
|---|---|---|
| Aerial Lines | 5 | C |
| Air Brakes | 5 | E |
| Air Compressors | 4 - 5 | D |
| Arc Lamps | 6 2/3 | E |
| " | 8 | C |
| Belting | 5 | E |
| Boilers | 3½ - 4 | D |
| " | 6 2/3 | C |
| " Water Tube | 5 | B |
| " Fire Tube | 6 2/3 | E |
| " Water Tube | 5 | E |
| " Fire Tube | 10 | A |
| Bonds | 5 | D |
| " | 50% wearing value | B |
| " | 5 | E |
| Breeching and Connections | 3½ - 10 | D |
| Buildings | 1½ | D |
| " Brick | 2 | B |
| " | 2-4 | E |
| " Wood | 2 | C |
| " | 2 | A |
| Cables, Underground, high tension | 5 | B |
| " Underground, low tension | 50% maintenance cost | B |
| " Aerial, lead covered | 6 2/3 | E |
| " Underground, lead covered | 4 | E |
| " Underground, lead covered | 5 | C |
| Coal and Ash Handling Machinery | 7 | D |
| " | 5 | B |
| " | 10 | E |
| Condensers | 4 | D |
| " | 5 | B |
| " | 5 | E |
| " | 6 2/3 | C |
| Conduits | 1 | B |
| " | 2 | E |
| " | 2 | C |
| Cross Arms | 8 1/3 - 12½ | E |
| Engines, Steam | 3-5 | D |
| " Steam | 5 - 7½ | B |
| " Gas | 6 2/3 | E |
| " Steam, slow speed | 5 | E |

| Property. | Depreciation Per cent per year. Straight line. | Key to Authority. |
|---|---|---|
| Engines, Steam, high speed | 6 2/3 | E |
| " | 5 | A |
| " | 6 2/3 | C |
| Feeders, weather proof insulation. | Dependent on observed wear | D |
| " " | 6¼ | E |
| Foundations, machinery | Same as life of apparatus supported | D |
| " | Same as life of apparatus supported | B |
| Fuel Oil Handling Machinery | 4 | D |
| Generators | 3 - 8 | D |
| " | 5 | B |
| " Modern type | 5 | E |
| " Obsolete type | 6 2/3 | E |
| " Steam turbo | 5 | E |
| " | 10 | A |
| " | 6 2/3 | C |
| Heaters | 4 - 6 | D |
| " Feed Water, closed | 3 1/3 | E |
| " Feed Water, open | 3½ | E |
| Meters, Electric Switchboard | 5 | E |
| " Electric Service | 6 2/3 | E |
| " Electric | 8 | C |
| Motors, Railway | 3 1/3 | D |
| " | By inspection | B |
| " | 5 | B |
| " | 5 | E |
| Paving | 50% wearing value | B |
| Piping and Covering | 4 - 4½ | D |
| " | 5 - 6 | B |
| " | 5 | E |
| " | 5 | A |
| " | 6 2/3 | C |
| Poles, Steel | 2 | B |
| " Wood in concrete | 5 | E |
| " Wood in earth | 5½ - 8 1/3 | E |
| " Iron | 2½ | E |
| " Wood | 10 | A |
| Pumps | 5 | D |
| " | 5 | B |
| " Small Steam | 6 2/3 | E |
| " | 5 | A |
| " | 6 2/3 | C |
| Rolling Stock, Open car bodies | 4 | D |
| " Open trailer bodies | 4 | D |
| " Closed car bodies | 5 | D |
| " Trucks | 3 1/3 | D |
| " Closed & open cars | 3 1/3 | B |
| " Trucks | 3 1/3 | B |
| " Car bodies and equipment | 6 2/3 | E |

| Property. | Depreciation Per cent per year. Straight line. | Key to Authority. |
|---|---|---|
| Stack | 3 | D |
| " Steel | 10 | B |
| Stokers, Fixed parts | 5 | D |
| " Moving parts | 20 | D |
| Storage Batteries | 5 | B |
| " | 6 2/3 | E |
| " | 5 | C |
| Switchboard and Wiring | 3 | D |
| " | 6 | B |
| " | 5 | E |
| " | 8 | C |
| Telephones | 10 | E |
| Track, Rail Joints | 5 | D |
| " Ties | 5 | D |
| " Rails | Dependent on observed wear | D |
| " Special work | 8 1/3 | E |
| " Straight and Special work | 50% wearing value | B |
| " Straight track | 5½ | E |
| Transformers, Station Service | 5 | E |
| " " | 6 2/3 | C |
| Turbines, Steam | 5 | E |
| " Water | 3 1/3 | E |
| " Steam | 6 2/3 | C |
| Wire, Trolley | Allowance of 80.5 lbs. per 1000 ft. for wearing value of No. 0 wire | D |
| " " | Allowance of 106.8 lbs. for No. 00 wire | D |
| " Trolley, 0 under 1 minute headway | 50 | E |
| " Trolley, 00 under 1 minute headway | 40 | E |
| " Trolley, 000 under 1 minute headway | 33 1/3 | E |
| " Weather proof | 6¼ | E |
| " " | 7½ | A |
| " " | 50% maintenance cost | B |

## TABLE 9.

**Pressure units used in Utility work and their equivalents at 32° F.**

| | | |
|---|---|---|
| 1 lb. per sq. in. | 2.309 | ft. of water |
| | 27.68 | in. of water |
| | 2.035 | in. of mercury |
| | 51.71 | m.m. of mercury |
| | 16. | oz. per sq. in. |
| | .068 | atmospheres |
| 1 atmosphere | 760.00 | m.m. of mercury |
| | 29.92 | in. of mercury |
| | 33.9 | ft. of water |
| | 14.7 | lb. per sq. in. |
| 1 in. of mercury | 25.4 | m.m. of mercury |
| | 13.6 | in. of water |
| | .49 | lb. per sq. in. |
| | 7.84 | oz. per sq. in. |
| | .033 | atmosphere |
| 1 in. of water | 1.868 | m.m. of mercury |
| | .073 | in. of mercury |
| | .036 | lb. per sq. in. |
| | .57 | oz. per sq. in. |
| | .002 | atmosphere |
| 1 oz. per sq. in. | 1.73 | in. of water |
| | .127 | in. of mercury |
| | .062 | lb. per sq. in. |

## TABLE 10.

**Variation in volume of 100 cu. ft. (100%) of gas at constant temperature under various gage pressures.**

| Pressure Per Sq. In. | Volume. |
|---|---|
| 0 oz. | 100.00% |
| 2 oz. | 99.1 |
| 4 oz. | 98.3 |
| 6 oz. | 97.5 |
| 8 oz. | 96.7 |
| 10 oz. | 95.9 |
| 12 oz. | 95.1 |
| 14 oz. | 94.3 |
| 1 lb. | 93.6 |
| 2 lb. | 88. |
| 3 lb. | 83. |
| 4 lb. | 78.6 |
| 5 lb. | 74.6 |
| 6 lb. | 71. |
| 7 lb. | 67.7 |
| 8 lb. | 64.7 |
| 9 lb. | 62. |
| 10 lb. | 59.5 |
| 12 lb. | 55. |
| 14 lb. | 51.5 |
| 16 lb. | 47.8 |
| 18 lb. | 44.9 |
| 20 lb. | 42.3 |
| 30 lb. | 32.8 |
| 40 lb. | 26.8 |
| 50 lb. | 22.7 |
| 75 lb. | 16.8 |
| 100 lb. | 12.8 |
| 150 lb. | 8.9 |
| 200 lb. | 6.8 |
| 250 lb. | 5.5 |
| 300 lb. | 4.6 |
| 400 lb. | 3.5 |

## TABLE 11.

### Effects of Altitude on Gas Apparatus Capacity.

| A<br>Elevation above sea level in feet | B<br>Barometric pressure in inches of mercury. | C<br>Relative capacity in per cent. |
|---|---|---|
| 0 | 29.92 | 100. |
| 500 | 29.35 | 98.9 |
| 1000 | 28.82 | 96.3 |
| 1500 | 28.30 | 94.5 |
| 2000 | 27.78 | 92.5 |
| 2500 | 27.27 | 91.0 |
| 3000 | 26.77 | 89.5 |
| 3500 | 26.28 | 87.8 |
| 4000 | 25.81 | 86.3 |
| 4500 | 25.34 | 84.7 |
| 5000 | 24.88 | 83.1 |
| 5500 | 24.42 | 81.6 |
| 6000 | 23.98 | 80.2 |
| 6500 | 23.54 | 78.6 |
| 7000 | 23.11 | 77.2 |
| 7500 | 22.69 | 75.8 |
| 8000 | 22.28 | 74.5 |
| 8500 | 21.87 | 73.2 |
| 9000 | 21.47 | 71.7 |

## TABLE 12.

### REFLECTING POWERS OF VARIOUS SURFACES.

| Nature of Surface. | Reflected. | % Light Lost by Absorption. |
|---|---|---|
| Mirror | 95 | 5 |
| White paper | 80 | 20 |
| Chrome yellow paper | 60 | 40 |
| Orange paper | 50 | 50 |
| Yellow paint (clean) | 40 | 60 |
| Light pink paper | 35 | 65 |
| Blue wall paper | 25 | 75 |
| Yellow paint (dirty) | 20 | 80 |
| Emerald green paper | 18 | 82 |
| Dark brown paper | 13 | 87 |
| Vermilion paper | 12 | 88 |
| Cobalt blue paper | 12 | 88 |
| Glossy black paper | 5 | 95 |
| Deep chocolate paper | 4 | 96 |
| Dead black surface | 1 | 99 |

## TABLE 13.

### Demand Factors for Electric Service Compiled by Wisconsin Railroad Commission.

| | | |
|---|---|---|
| Stores | 40 to | 100 |
| Offices | 57 | 87 |
| Saloons | 62 | 92 |
| Restaurants | 52 | 62 |
| Factories | 53 | 56 |
| Churches | 56 | 85 |
| Hotels | 28 | |
| Clubs | 28 | |
| Schools | 37 | 52 |
| Laundries | 60 | 75 |
| Livery Stables | 52 | 58 |
| Lodge and Dance Halls | 68 | |
| Depots | 75 | 95 |
| Theaters | 49 | 89 |
| Shops | 55 | |
| Machine Shops | 37 | 54 |
| Blacksmith Shops | 66 | |
| County and Federal Buildings | 33 | 31 |
| Residences .3 K. W. Connected load | | 96 |
| " .5 " " " | | 64 |
| " 1.0 " " " | | 48 |
| " 2.0 " " " | | 46 |

## TABLE 14.

### MONTHLY AVERAGE TIME BETWEEN SUNSET AND SUNRISE AND OF UTILITY LIGHTING SERVICE USE.

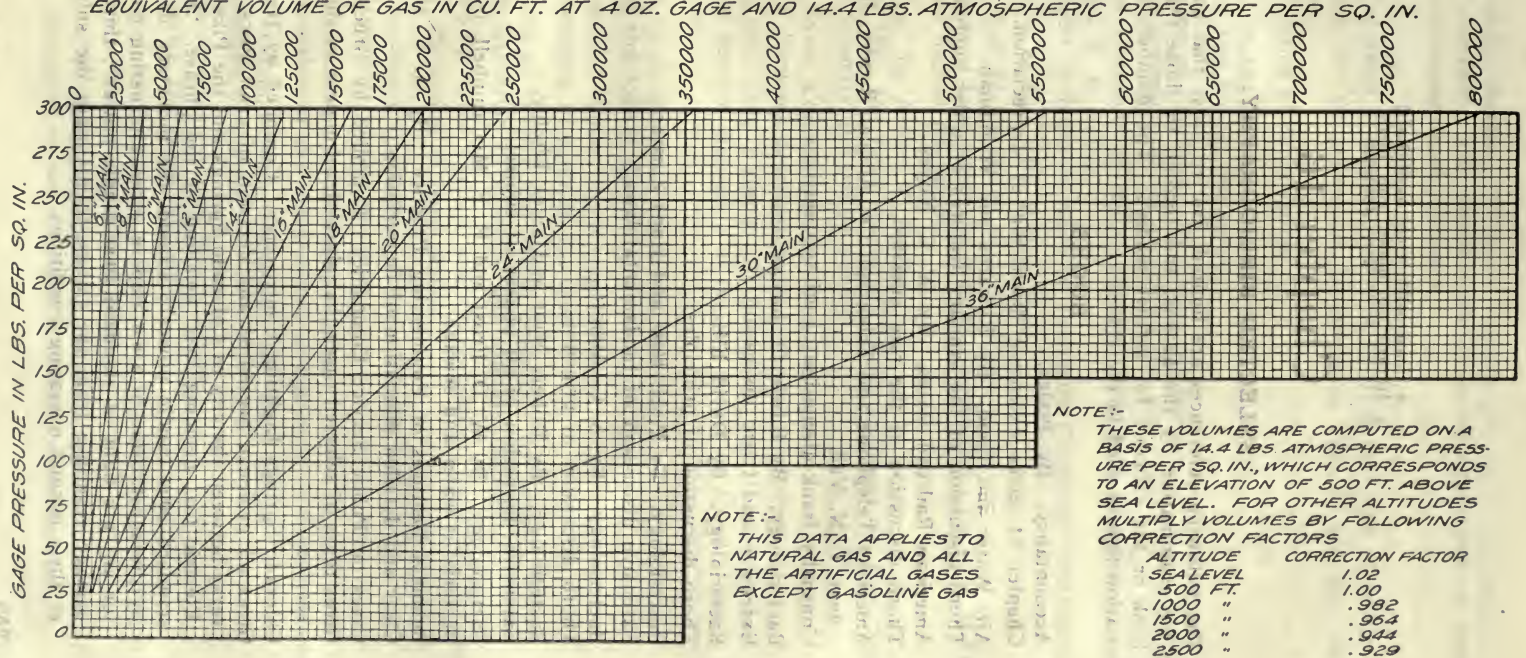
| | Time between sunset and sunrise. | Hours Sleep. | Time of lighting service use. |
|---|---|---|---|
| Jan. | 14 hr. 27 min. | 8 hrs. | 6 hrs. 27 min. |
| Feb. | 13 " 23 " | " " | 5 " 23 " |
| Mar. | 12 " 9 " | " " | 4 " 9 " |
| Apr. | 10 " 45 " | " " | 2 " 45 " |
| May | 9 " 35 " | " " | 1 " 35 " |
| June | 8 " 56 " | " " | 56 " |
| July | 9 " 9 " | " " | 1 " 9 " |
| Aug. | 10 " 8 " | " " | 2 " 8 " |
| Sept. | 11 " 28 " | " " | 3 " 28 " |
| Oct. | 12 " 48 " | " " | 4 " 48 " |
| Nov. | 14 " 2 " | " " | 6 " 2 " |
| Dec. | 14 " 42 " | " " | 6 " 42 " |
| Average | 11 " 47 " | " " | 3 " 47 " |

# TABLE 15

## RESULTS FROM REMOVAL OF WATER MAIN GROWTHS

| LOCATION | Diameter of Pipe in Inches | Length of Line Tested in Feet | Discharge in Gallons Per Minute | | Nature of Stoppage |
|---|---|---|---|---|---|
| | | | Before Cleaning | After Cleaning | |
| Philadelphia, Pa. | 6 | 447 | 364 | 710 | Mud and iron corrosion. |
| Brooklyn, N. Y. | 6 | 806 | 176 | 623 | Iron corrosion. |
| Brooklyn, N. Y. | 8 | 680 | 349 | 877 | Iron corrosion. |
| Brooklyn, N. Y. | 12 | 950 | 1235 | 3754 | Iron corrosion. |
| Perth Amboy, N. J. | 4 | 500 | 247 | 477 | Iron corrosion. |
| Perth Amboy, N. J. | 6 | 601 | 561 | 739 | Iron corrosion. |
| Pittsburg, Pa. | 8 | 3264 | 730 | 1620 | Iron corrosion. |
| Belle Plain, Ia. | 6 | 5044 | 248 | 335 | Lime deposit. |
| Troy, N. Y. | 6 | 410 | 443 | 703 | Iron corrosion. |
| Camden, N. J. | 4 | 420 | 100 | 227 | Iron corrosion. |
| Cumberland, Md. | 6 | 2200 | 403 | 802 | Slime, mud and iron corrosion. |
| Madison, Ind. | 4 | 924 | 90 | 262 | Mud and iron corrosion. |
| Lockport, N. Y. | 6 | 1100 | 315 | 742 | Slime and iron corrosion. |
| Little Rock, Ark. | 6 | 1090 | 374 | 1021 | Iron corrosion. |
| Pittsburg, Pa. | 6 | 1800 | 252 | 671 | Iron corrosion. |
| Pittsburg, Pa. | 4 | 1834 | 178 | 384 | Iron corrosion. |
| Pittsburg, Pa. | 4 | 905 | 160 | 485 | Iron corrosion. |
| New York City, N. Y. | 6 | 650 | 435 | 765 | Iron corrosion. |
| Rochester, N. Y. | 10 | 1045 | 1125 | 1740 | Iron corrosion. |

# FIG. 47
# VOLUME OF GAS STORED IN ONE MILE OF VARIOUS SIZE GAS MAINS




NOTE:-
THIS DATA APPLIES TO NATURAL GAS AND ALL THE ARTIFICIAL GASES EXCEPT GASOLINE GAS

NOTE:-
THESE VOLUMES ARE COMPUTED ON A BASIS OF 14.4 LBS. ATMOSPHERIC PRESSURE PER SQ. IN., WHICH CORRESPONDS TO AN ELEVATION OF 500 FT. ABOVE SEA LEVEL. FOR OTHER ALTITUDES MULTIPLY VOLUMES BY FOLLOWING CORRECTION FACTORS

| ALTITUDE | CORRECTION FACTOR |
|---|---|
| SEA LEVEL | 1.02 |
| 500 FT. | 1.00 |
| 1000 " | .982 |
| 1500 " | .964 |
| 2000 " | .944 |
| 2500 " | .929 |

A man will turn over half
a library to make one book.
—Dr. Johnson.

# Chapter 16

## SELECTED BIBLIOGRAPHY.

The following references are limited, first to those that have been available for examination by the author, and second, to those that are cited in the book or are valuable for further reading. The numbers at the left are the citation figures used in the text.

### BOOKS.


1. Accountancy. By Pixley.
   Chapter 11 gives extensive discussion of depreciation.
2. Air, Water and Food. By Richards and Woodman.
   Thoro discussion of the sanitary features of water supplies.
3. American Railroad Rates. By W. C. Noyes.
   Thoro discussion of the rate question.
4. American Telephone and Telegraph Co. Annual Report, 1910. By President T. N. Vail.
   Unusually frank discussion of utility questions.
5. Bacteriology. By Edwin O. Jordan.
   Extensive and thoro discussion.
6. Bacteriology. By David Ellis.
   Thoro discussion of principles.
7. Bacteriology. By P. H. Hiss and Hans Zinsser.
   Extensive discussion of fundamental laws.
8. Bacteriology. By A. C. Abbott.
   Thoro discussion of principles.
9. Bacteriology. By Robert Muir andJames Ritchie.
   Extensive discussion of all phases of subject.
10. Bacteriology. By W. D. Frost and E. F. McCampbell, p. 293.
    Bacteria of water and sewage.
11. Business Features of Engineering Practice. By A. C. Humphreys.
    Clear and detailed discussion of depreciation.
12. Cases on Public Service Companies. Compiled by Bruce Wyman.
    Gives texts of selected cases that show development of the law of public service.
13. Colorado Springs Lighting Controversy. Compiled by Henry Floy.
    Gives all evidence presented and decision of arbitrators in the controversy between the city of Colorado Springs and the Pike's Peak Hydro-Electric Co., deciding first, meaning of the phrase, "An arc light of standard 2000 candle power"; second, the monetary damage accruing by the substitution of a 6.6 ampere series alternating current arc lamp for an "arc light of standard 2000 candle power"; third, the financial damage resulting from the failure to maintain the substituted lamps at their normal operating conditions.

14. Control of the Market. By Bruce Wyman.
Unique, interesting and valuable discussion of application of common law to economic legal problems.

15. Cost of Living. By Ellen H. Richards.
Thoro discussion of economic factors entering into cost of living.

16. Cyclopedia of Commerce and Accountancy. Vol. 6, pp. 126, 168, 225 and 260.
Brief discussion of depreciation.

17. Depreciation and Wasting Assets. By P. D. Leake.
Analytical and logical discussion.

18. Depreciation of Factories. By Ewing Matheson.
Extensive discussion of the principles and applications of depreciation.

19. Digest of Decisions of the Courts and Interstate Commerce Commission. By E. B. Peirce.
Thoro digest of decisions made by Interstate Commerce Commission.

20. Distribution of Gas. By Walter Hole.
Chapter 33 gives discussion of electrolysis.

21. Due Process of Law under the Federal Constitution. By L. P. McGehee.
Thoro and logical discussion.

22. Economics. By Arthur T. Hadley.
Unusually thro, but brief, discussion of the economic relations between private property and public welfare.

23. Electric Power Conductors. By Wm. Del Mar.
Chapter 9 discusses depreciation of electrical equipment.

24. Electric Law. Vols. 1 and 2. By Joseph A. and Howard C. Joyce.
Thoro and detailed discussion of the law pertaining to all Utilities using electricity.

25. Elements of Economics. By H. D. Macleod.
Extensive and logical discussion of economic laws.

26. Examination of Water. By Henry Leffmann.
Thoro discussion of sanitary features.

27. Examination of Waters and Water Supplies. By John C. Thresh.
Extensive discussion of chemical and sanitary features.

28. Federal Power Over Carriers and Corporations. By E. P. Prentice.
Analytical discussion of legal phases.

29. Federal Regulation of Railway Rates. By Merritt.
Concise treatment of rate question.

30. Federal Usurpation. By Franklin Pierce.
Thoro discussion of the unwarranted enlargement of Federal power.

31. Filtration of Public Water Supplies. By Allen Hazen.
Clear discussion of subject.

32. Fourteenth Amendment. By Henry Brannon.
Comprehensive and thoro discussion.

33. Goodwill and Its Treatment in Accounts. By Dicksee and Tillyard.
Extensive and thoro discussion of subject.

34. Highways of Progress. By James J. Hill.
Valuable discussion of the economic problems of transportation.

35. Jurisprudence Law and Ethics. By E. B. Kinkaid.
28 concise and pointed lectures on subject.

36. Laws Relating to Street Railway Franchises in the District of Columbia.
Pages 14 and 89 relate to electrolysis prevention.

37. Law, Its Origin, Growth and Function. By James C. Carter.
Extensive, thoro and unique treatment of subject.

38. Law Relating to Conflicting Uses of Electricity and Electrolysis. By G. F. Deiser.
Thoro and analytical discussion. Gives all electrolysis cases.

39. Law of Telegraph and Telephone Companies. By Jones.
Extensive discussion of all legal phases.

40. Law of Street Railroads. Vols. 1 and 2. By Nellis.
Thoro treatment of all phases of subject.

41. Laws relating to the Regulation of Telephone and Telegraph Companies by Commission. Compiled by American Telephone and Telegraph Company.
Gives summary of all laws in force in United States November, 1, 1911.

42. Legal Doctrine and Social Progress. By Frank Parsons.
Brief discussion of relation of law and progress.

43. Legal Phases of Central Station Rate Making. By James V. Oxtoby.
Thoro legal and economic discussion of the status of the wholesale and special customer and reasonable profit, its definition, collection and distribution. Printed for private circulation ONLY.

44. Lectures on Electrical Engineering. By C. P. Steinmetz.
Unusually clear presentation of subject.

45. Lectures on Illuminating Engineering. Johns Hopkins University.
Vol. 2, p. 945.
Commercial Aspects of Electric Lighting. By J. W. Lieb, Jr.
P. 1009 Commercial Aspects of Gas Lighting. By Walton Clark.

46. Microbiology. Edited by C. E. Marshall.
Thoro discussion of the bacteriological problems of water.

47. Municipal Franchises. Vols. 1 and 2. By D. F. Wilcox.
Discusses all kinds of Utility franchises and gives quotations from many franchises now in force.

48. Municipal Monopolies. By E. W. Bemis.
Extensive discussion of economic and legal phases.

49. Natural Law in the Business World. By Henry Wood.
Interesting, valuable and logical discussion.

50. Nature and Sources of the Law. By John Chipman Gray.
Original and valuable discussion.

51. Outlines of Economics. By Richard T. Ely.
Gives brief, but pointed, discussion of economic laws.

52. Prices Charged for Gas. By S. J. Glass, of Milwaukee Gas and Light Co., Milwaukee, Wis.
Gives prices of artificial gas in 172 typical American cities from 1885 to 1907.

53. Problems of Today. By Richard T. Ely.
Clear discussion of natural monopolies.

54. Public Service Corporations. Vols. 1 and 2. By Bruce Wyman.
Extensive and thoro discussion of the legal phases of Utility problems.

55. Public Water Supplies. By F. E. Turneaure and H. L. Russell.
Thoro discussion of subject.

56. Radiation, Light and Illumination. By C. P. Steinmetz.
Thoro discussion of general principles.

57. Railway Corporations as Public Servants. By Henry Haines.
General discussion of public relations of railroads.

58. Railway Library 1909. By Slason Thompson.
Gives statistical data pertaining to railroads.

59. Railway Library 1910. By Slason Thompson.
Gives statistical data pertaining to railroads.

60. Railway Legislation in the United States. By B. H. Meyer.
Brief, but thoro, discussion.

61. Railroad Rate Regulation. By Beale and Wyman.
Thoro and comprehensive discussion of all legal phases.
This is practically the same as 54.

62. Rate Regulation of Gas and Electric Lighting. By Van Sinderen Lindsley.
Brief discussion of several cases, with compilation of the regulation statutes of the various states.

63. Rate Theories of the Interstate Commerce Commission. By M. B. Hammond.
Brief, but thoro, discussion of principles underlying Interstate Commerce Commission's decisions.

64. Stray Currents from Electric Railways. By Michalke.
Brief, but good, discussion; gives short bibliography.

65. Supremacy of Law. By Bishop John P. Newman.
Thoro and interesting discussion.

66. Telephony. By McMeen and Miller.
Brief discussion of electrolysis in Chapter 50.

67. Telephone Law. By McMillan.
Thoro discussion of all phases.

68. Theory of Value. By Wm. Smart.
Brief but clear and logical treatment.

69. Trusts and Monopolies. By Spelling.
Thoro discussion of legal phases.

70. Typhoid Fever. By George C. Whipple.
Unusually thoro treatment of subject; gives much valuable data relating to water Utilities.

71. Valuation of Public Utility Properties. By Henry Floy.
Extensive discussion of valuation problems.

72. Valuation of Public Utilities and Factories. By Horatio A. Foster.
Extensive discussion of valuation problems, giving typical forms used.

73. Valuation of Public Service Corporations. By Robert H. Whitten.
Voluminous discussion of legal phases; gives digest of much data not ordinarily available.

74. Value of Pure Water. By G. C. Whipple.

Brief, but valuable and interesting, discussion.

75. Water and Public Health. By James H. Fuertes.
Brief discussion of subject.

76. Water Rights in Western States. Vols. 1. and 2. By Wiel.
Thoro discussion.

77. Water Supply. By William P. Mason.
Extensive discussion of sanitary features.

## MAGAZINES AND TECHNICAL SOCIETIES.

### American Economic Association Bulletin.

78. Sept., 1911, p. 473. Thoro and analytical discussion of the economic features of Utility rates; by J. Maurice Clark.

### American Electrochemical Society.

79. Vol. 3, p. 195. Thoro discussion of electrolysis, by A. A. Knudson.

### American Gas Institute.

80. Vol. 1, p. 276. Discussion of gas rates; gives bibliography of rate question containing 215 references; by W. H. Gardner, Jr., H. L. Doherty, Geo. McLean.

81. Vol. 1, p. 761. Extensive discussion of electrolysis troubles at Peoria, Ill.; Taunton, Mass.; Dayton, O.; Richmond, Va.; New Bedford, Mass.; Bayonne, N. J.; Boston, Mass.; Chicago, Ill.; Detroit, Mich.; New York City, Great Britain and Germany; by A. G. Glasgow, John Williamson, S. P. Curtis, Arthur H. Hall, Prof. A. F. Ganz.

82. Vol. 2, p. 307. Extensive discussion of depreciation, by A. C. Humphreys.

83. Vol. 2, p. 653. Extensive discussion of electrolysis, by Prof. A. F. Ganz.

84. Vol. 6, p. 234. Thoro discussion of insulation as a means of minimizing electrolysis in underground pipes. Gives results of special work of U. S. Bureau of Standards, by E. B. Rosa and Burton McCollum.

### American Gas Light Association.

85. Vol. 21, p. CXIII. Thoro discussion of methods of charging for gas, by F. W. Frueaff.

### American Gas Light Journal.

86. Vol. 71, p. 966. Extensively illustrated discussion of Electrolysis, by F. A. W. Davis.

### American Institute Electrical Engineers.

87. Vol. 11, p. 191. Extensive discussion of electrolysis, with special reference to telephone cables; by I. H. Farnham.

88. Vol. 26, part I., pp. 201 and 264. Thoro discussion of alternating current electrolysis, by J. L. R. Hayden.

89. Vol. 26, part I., p. 245. Brief, but valuable discussion of electrolytic corrosion of iron and steel in concrete, by A. A. Knudson.
Gives results of numerous tests and observations.

90. Vol. 26, part I, p. 247. Thoro and analytical discussion of the reduction of earth currents from electric railways by means of negative or return feeders, by George I. Rhodes.

91. Vol. 26, part I, p. 286. Pointed discussion of rules governing return feeders to reduce stray currents from electric railways, by Albert F. Ganz.

92. Vol. 27, part I, p. 335. General discussion of engineer's relation with valuation questions, by Henry Floy.

93. Vol. 28, p. 1372. Pointed discussion of electric power costs, by H. L. Doherty.

94. Vol. 28, p. 1479. Thoro discussion of electric power costs, by H. G. Stott.

95. Vol. 29, p. 375. Illustrated discussion of diversity factor, by H. B. Gear.

96. May, 1911, p. 939. Brief, but thoro, discussion of electrolytic corrosion, by C. E. Magnusson and G. H. Smith.

97. June, 1911. Extensive discussion of depreciation, by Henry Floy.

98. Aug., 1911. Electrical engineers and the public, by Dugald C. Jackson.

99. Sept., 1911. Responsibilities of engineers in making appraisals, by H. M. Byllesby.

100. Feb., 1912. Analytical and detailed discussion of relation of load curves and power costs, by G. I. Rhodes.

**American Law Review.**

101. Vol. 37, p. 654. Valuable light on real comprehensive scope of 14th amendment, by Judge Alton B. Parker.

**American Society Civil Engineers.**

102. Vol. 31, p. 220. Extensive discussion of action of wood borers, by R. Montfort.

103. Vol. 38, p. 1. Pointed discussion of water works financing, by E. Kuichling.

104. Vol. 38, p. 115. Thoro, but brief, discussion of water works valuation, by Wynkoop Kiersted.

105. Vol. 40, p. 178. Thoro and illustrated discussion of marine wood borers, by C. H. Snow.

106. Vol. 64, p. 1. Extensive discussion of water works valuation and fair rates; gives bibliography; by Leonard Metcalf.

107. Vol. 64, p. 112. Thoro and valuable discussion of purification of ground waters containing iron and manganese, by R. S. Weston.

108. Vol. 72, p. 1. Thoro discussion of the methods used in fixing the value of the Michigan R. R. property, gives blank forms used, methods of work and a bibliography, by H. E. Riggs.

109. Vol. 73, p. 326. Pointed discussion of the "Going value of water works," by Leonard Metcalf and J. W. Alvord.

110. Jan., 1912, p. 19. Extensive discussion of just value of monopolies and the regulation of the prices of their products, by Joseph Mayer.

111. April, 1912, p. 395. Thoro discussion of appraisal of public service properties as a basis for the regulation of rates, by C. E. Grunsky.

**American Society Mechanical Engineers.**

112. Vol. 10, p. 499. Comparative cost of steam and water power, by C. H. Manning.

113. Vol. 11, p. 108. Comparative cost of steam and water power, by C. T. Main.

114. Vol. 13, p. 140. Value of a water power, by C. T. Main.

115. Vol. 21, p. 590. Value of a horse power and stream diversion damages, by G. I. Rockwood.

116. Vol. 24, p. 286. Commercial value of a water power per horse power, by A. F. Nagle.

117. Vol. 25, p. 120. Method for determining rates and prices for electric power, by F. B. Perry.

118. Vol. 25, p. 550. Tests of freight locomotives, by Prof. E. A. Hitchcock.

119. Vol. 26, p. 297. Tests of passenger locomotives, by Prof. E. A. Hitchcock.

**American Academy of Political and Social Science.**

120. Vol. 2, p. 702. The state and lighting corporations, by Walter S. Allen.

**American Water Works Association.**

121. Vol. 1897, p. 157. Depreciation due to electrolysis of water mains, by F. C. Kelsey.

122. Vol. 1899, p. 234. Notes on depreciation due to electrolysis of water mains, by E. E. Brownell.

123. Vol. 1890, p. 121. Thoro discussion of depreciation due to electrolysis, shows stand pipe wrecked by pitting action of electrolysis, by D. H. Maury.

124. Vol. 1901, p. 76. Depreciation due to electrolysis of water mains, by D. H. Maury, G. H. Benzenberg, J. Walso Smith.

125. Vol. 1903, p. 209. Action of electrolysis in depreciating water mains, by D. H. Maury.

126. Vol. 1903, p. 473. Valuable discussion of depreciation; gives observed life of 50 pumping engines, by J. W. Alvord.

127. Vol. 1903, p. 524. Thoro and illustrated discussion of crenothrix growths in water mains, by Erastus G. Smith.

128. Vol. 1904, p. 148. Depreciation due to growths in water mains, by O. T. Smith.

129. Vol. 1904, p. 161. Monthly cost of cast iron pipe from 1883 to 1904, by J. W. Alvord.

130. Vol. 1904, p. 251. Large amount of statistical data pertaining to water works; gives water rates in 88 towns, by John B. Heim.

131. Vol. 1907, p. 33. Rates for water service, by D. H. Maury.

132. Vol. 1907, p. 303. Depreciation of water mains due to tuberculation, by N. S. Hill, Jr.

133. Vol. 1908, p. 209. Water rates charged in 375 towns, by D. R. Gwinn.

134. Vol. 1909, p. 1. Valuation of water power and the estimation of stream diversion damages, by R. E. Horton.

135. Vol. 1909, p. 184. Thoro discussion of going value and methods for its computation, by J. W. Alvord.

136. Vol. 1910, p. 25. Report of committee on depreciation.

137. Vol. 1911, p. 39. Valuable discussion of results of water main cleaning, by B. B. Hodgman.

138. Vol. 1911, p. 55. Thoro discussion of fire hydrant service rates, gives much valuable data and rates paid in 125 towns, by Leonard Metcalf, Emil Kuchling and W. C. Hawley.

139. Vol. 1911, p. 173. Thoro and analytical discussion of water rates, by George G. Earl.

140. Vol. 1912. Extensive and thoro discussion of electrolysis, gives much valuable data, by Prof. Albert F. Ganz.

**Association Engineering Societies.**

141. Vol. 13, p. 509. Thoro discussion of electrolysis of iron pipes, by L. C. Jackson.

142. Vol. 31, p. 49. Illustrated discussion of the action of sea worms on timber, by F. W. Hodgon.

143. Vol. 36, p. 37. Detailed discussion of valuation of water works for rate fixing purposes, by A. L. Adams.

144. Vol. 39, p. 336. Thoro discussion of methods of appraisal and depreciation, gives prices of cast iron pipe from 1889 to 1908, also opinions of various authorities on depreciation rates, by W. H. Bryan.

**Bankers' Magazine.**

145. July, 1907, p. 3. Strong argument against violation of railroads by Federal Government.

**Bell Telephone News.**

146. Feb., 1912, p. 12. Pointed discussion of telephone rates, by H. O. Seymour.

147. March, 1912, p. 12. Problems of telephone rate making, by Alonzo Burt.

148. May, 1912, p. 12. Thoro discussion of electrolysis testing, by J. M. Humiston.

**Bulletin of the League of American Municipalities.**

149. Vol. 6, p. 181. Domestic and street lighting electric rates in 78 private and 9 municipal plants in typical American cities.

**Canadian Electrical Engineers' Association.**

150. Vol. 1910, p. 57. Thoro discussion of electric service rates, by S. B. Hood.

**Cassiers' Magazine.**

151. Vol. 16, p. 371. Illustrated discussion of electrolysis, by A. V. Abbott.

152. Vol. 32, p. 304. Discussion of cost of electric power in European plants, gives extensive schedules of rates, by C. S. Vesey-Brown.

153. Vol. 35, p. 402. Legal, economic and engineering phases of rate regulation of electric power, by S. S. Wyer.

**Electrical Age.**

154. Vol. 36, p. 410. Illustrated discussion of Wright demand system for charging for electric power.

155. Vol. 38, p. 132. Thoro discussion of equitable methods of charging for electric power.

156. Vol. 38, p. 257. Discussion of the effect of power factor on equitable electric power rates.

157. Vol. 38, p. 410. Pointed discussion of effect of load factor on power costs.

**Electric Railway Journal.**

158. Vol. 35, p. 76. General discussion of valuation, shows futility of attempting to fix rates on mere physical valuation, by W. H. Williams.

**Electrical World.**

159. Vol. 56, p. 567. Influence of demand and diversity factors on electric rates, by J. R. Cravath.

**Engineering Contracting.**

160. Vol. 36, p. 188. Thoro discussion of electrolysis in water mains, with special reference to Pittsburg, Pa., and Chicago, Ill.

161. Vol. 36, pp. 289, 332, 445, 473. Extensive discussion of telephone valuation.

162. Vol. 37, p. 708. Thoro discussion of going value, by H. P. Gillette.

**Engineering Magazine.**

163. Vol. 15, p. 451. Brief, but pointed, discussion of electrolysis, by A. B. Herrick.

164. Vol. 33, p. 849. Value and economic effect of railroad improvements. by M. W. Gaines.

165. Vol. 34, p. 311. Study of private electric lighting service costs, gives rates for street lighting in 25 American cities, by J. H. Boughton.

166. Vol. 35, p. 168. Cost of steam power in small units, by W. E. Snow.

167. Vol. 35, p. 562. Cost of steam power in varying units, by W. O. Webber.

168. Vol. 35, p. 825. Extensive discussion of conservation of water power resources, by H. von Schon.

169. Vol. 36, p. 1. Good description of the equipment and work of The United States Bureau of Standards, by H. T. Wade.

170. Vol. 38, p. 394. Thoro analytical discussion of large electric power contracts, by H. S. Knowlton.

171. Vol. 39, p. 230. Brief study of power costs, by W. O. Webber.

172. Vol. 39, p. 569. Analytical study of the economic causes of high prices. by Alex Del Mar.

173. Vol. 39, p. 693. Ethics of depreciation allowance, by L. S. Randolph.

174. Vol. 40, p. 329. Thoro discussion of the economic features of monopoly as related to unified control in Utility work, by Sylvester Baxter.

175. Vol. 40, pp. 489 and 841. Analytical discussion of monopoly, by Dr. Franz Erich Junge-Hermsdorf.

176. Vol. 41, p. 33. Illustrated discussion of engineering solution of freight-handling problem, by H. McL. Harding.

177. Vol. 41, p. 406. Discrimination in central station rates.
Thoro analysis, by F. F. Fowle.

178. Vol. 42, p. 1. Extensive and thoro discussion of efficiency in railroad operation, by B. A. Franklin, E. P. Ripley, Julius Kruttschitt, Harrington Emerson and Louis D. Brandeis.

179. Vol. 42, p. 488. Thoro discussion of rates; unit costs and efficiency of railroads; gives unit costs on 20 large railroads in United States, by F. L. Hutchins.

180. Vol. 42, p. 873. Some criteria of value in public service industries, by Clarence P. Fowler.

**Engineering News.**

181. Vol. 52, p. 437. Illustrated discussion of electrolysis damages at Bayonne, N. J.

182. Vol. 62, p. 231. Thoro discussion of a scale for charging for public utilities, by W. D. Marks.

183. Vol. 63, p. 396. Thoro and illustrated discussion of sliding scale for electric power rates, by J. B. Gordon.

184. Vol. 64, p. 411. Extensive and thoro discussion of valuation of telephone properties.

185. Vol. 64, p. 648. Thoro discussion of rational basis for telephone rates, by D. C. Jackson.

**Engineering Record.**

186. Vol. 60, p. 147. Brief discussion of electrolysis conditions at Winnipeg, by Prof. L. A. Herdt.

187. Vol. 65, p. 174. Discussion of an unusual railroad appraisal, by Prof. G. F. Swain.

**Engineers' Society of Western Pa.**

188. Vol. 27, p. 235. Extensive discussion of electrolysis conditions in Pittsburg, Pa., by E. E. Lampher and L. B. Smith.

**Franklin Institute.**

189. Vol. 165, p. 397. Opinions of various authorities on life of power plant equipment.

**General Electric Review.**

190. Vol. 14, p. 157. Real theory of real electric rates, by R. S. Hale.

**Illinois Gas Association.**

191. Vol. 1909, p. 108. Thoro discussion of the comparative values of various coatings and coverings for the prevention of soil and electrolytic corrosion of iron pipe, by R. B. Harper.

**Institution of Electrical Engineers. (British.)**

192. Vol. 48, p. 376. Thoro and extensive discussion of residence electric rates, by A. H. Seabrook.

**International Electrical Congress at St. Louis.**

193. Vol. 3, p. 666. Symposium on electrolysis, gives data pertaining to conditions in 94 American cities.

**Journal of Accountancy.**

194. Vol. 5, p. 189. Discussion of depreciation, by Alfred Knight.

195. Vol. 6, p. 177. Pointed discussion of law governing promoters, by H. E. Barnes.

196. Vol. 6, p. 229. Depreciation in railway accounting, by J. F. Calvert.

197. Vol. 9, pp. 89, 104 and 189. Depreciation, renewal and replacement accounts, by H G. Stockwell.

**Journal of Electricity, Power and Gas.**

198. Vol. 15, p. 331. Thoro discussion of legal and economic phases of regulation question, by H. C. Brown.

**Journal of Infectious Diseases.**

199. Vol. 7, p. 510. Thoro and valuable discussion of the decrease in mortality from diseases other than typhoid fever following the purification of public water supplies, by W. T. Sedgwick and J. S. MacNutt.

**Junior Engineering Society.**

200. Vol. 3, p. 33. Unusually thoro and unique discussion of cost of electric service, by Dr. John Hopkinson.

**Municipal Journal and Engineer.**

201. Vol. 28, p. 19. Gives summary of electrolysis regulations prescribed by 10 European cities.

202. Vol. 29, p. 744. Brief discussion of depreciation and present value, by C. S. Burns.

**National Civic Federation Commission.**

203. Vol. 1. Report on public ownership and operation.

**National Commercial Gas Association.**

204. 1910, p. 297. Thoro and logical discussion of rate question, with bibliography, by H. L. Doherty.

**National Electric Light Association.**

205. 32d Convention, Vol. 2, p. 586. Thoro discussion of load factors, by E. W. Lloyd.

206. 33d Convention, Vol. 2, p. 291. Tabulated data on demand factors, by G. E. McKana and B. F. McGuire.

207. 34th Convention, Vol. 1, p. 261. Breadth of view in Utility appraisals, by H. M. Byllesby.

208. 34th Convention, Vol. 1, p. 271. Elements affecting the fair valuation of plant and property, by W. F. Wells.

209. 34th Convention, Vol. 1, p. 290. Thoro discussion of electric rates, by J. F. Gilchrist.

**New England Association Gas Engineers.**

210. Vol. 1904-5, p. 257. Brief discussion of dangers of grounding electric wires to gas pipes, by E. H. Yorke.

211. Vol. 1906-7-8, p. 108. Brief discussion of electrolysis, by several members.

212. Vol. 1906-7-8, p. 287. Thoro discussion of readiness-to-serve cost of gas supply, by W. H. Gardiner.

**New England Water Works Association.**

213. Vol. 9, p. 25. Brief discussion of electrolysis, by C. A. Stone and H. C Forbes.

214. Vol. 10, p. 33. Pointed discussion of electrolysis, by Prof. H. A. Storrs.

215. Vol. 19, p. 322. Report of committee on water meter rates, gives rates in 72 towns.

216. Vol. 20, p. 34. Topical discussion of electrolysis.

217. Vol. 23, p. 164. Lead covered cables as a cause of electrolysis upon water and gas pipes, by A. A. Knudson.

218. Vol. 23, p. 180. Thoro discussion of grounding electric light wires on water pipes, by F. E. Merrill.

219. Vol. 24, pp. 25 to 160. Gives much valuable data pertaining to 233 stream diversion valuations for damages.

220. Vol. 24, p. 161. Extensive bibliography of stream diversion damages.

221. Vol. 24, p. 187. Thoro discussion of the legal aspects of riparian water rights and stream diversion suits, by C. F. Choate, Jr.

**Ohio State Board of Health, Monthly Bulletin.**

222. Aug., 1912, p. 237. Brief, but valuable, discussion of algae and their relation to public water supplies, by L. H. Van Buskirk.

**Pacific Coast Gas Association.**

223. Vol. 6, p. 59. Thoro discussion of gas compression problems, by E. A. Rix.

**Pacific Gas and Electric Magazine.**

224. Vol. 2, p. 86. Electric lighting rates in 58 American cities.

**Public Service.**

225. Vol. 1, p. 57. Valuable discussion of telephone competition, by H. J. Gonden.

226. Vol. 3, p. 105. Pointed discussion of regulation problems, by H. J. Gonden.

227. Vol. 3, p. 196. Brief discussion of telephone rates.

228. Vol. 4, p. 12. Discussion of gas standards, by A. E. Forstall.

229. Vol. 6, p. 127. Rates for water service, by D. H. Maury.

230. Vol. 7, p. 5. What is a fair return upon a Utility investment, by W. H. Winslow.

231. Vol. 7, p. 145. Equitable rates for public service, by D. C. Jackson.

232. Vol. 9, p. 6. Summary Chicago telephone rates.

233. Vol. 9, p. 13. Pointed discussion of relations of Utilities and public, by H. L. Doherty.

234. Vol. 9, p. 53. Brief discussion of 5-cent street car fares.

235. Vol. 9, p. 75. Brief discussion of traction fares, by Bion J. Arnold.

236. Vol. 10, p. 51. Why telephones should be metered, by F. H. Bethel.

237. Vol. 10, p. 82. Thoro discussion of water works depreciation, by Leonard Metcalf.

238. Vol. 10, p. 114. Analytical discussion of development expense, by H. P. Gillette.

239. Vol. 10, p. 134. How cost of materials entering into Utility plants has increased in 10 years, by W. F. Brashears.

240. Vol. 11, p. 53. Adjustment of street car fares, by G. H. Davis.

241. Vol. 11, p. 71. Brief discussion of depreciation of street railways, by W. B. Jackson.

242. Vol. 11, p. 74. Thoro discussion showing that telephone service costs more in large cities than in small.

243. Vol. 11, p. 117. Why going values must be allowed in appraisements, by C. S. Burns.

244. Vol. 11, p. 119. Thoro and analytical discussion of rates for electric current, by Halford Erickson.

245. Vol. 12, p. 47. Analytical discussion of street railway finances, by C. N. Duffy.

**Public Service Regulation.**

246. Vol. 1, p. 33. Brief discussion of water rates, by G. C. Mathews.

247. Vol. 1, p. 294. Thoro discussion of principles of valuation of Utilities, by Halford Erickson.

**Quarterly Journal of Economics.**

248. Aug., 1911, p. 623. Thoro and analytical discussion of street railway rates, by G. P. Watkins.

**Railroad Age Gazette.**

249. Vol. 45, pp. 587 and 627. Thoro discussion of fallacy of attempting to base railroad rates on mere physical valuation, by Henry Fink.

250. Vol. 46, pp. 173, 219, 261 and 312. Extensive discussion of valuation of railroads.

251. Vol. 48, p. 359. Thoro discussion of methods used in State of Washington for valuation of railroads, by J. C. Lawrence.

**Stevens' Indicator.**

252. Vol. 18, p. 163. Brief discussion of electrolysis at Brooklyn, N. Y., by H. E. McGowan.

**St. Louis Public Service Commission.**

253. Report on rates for electric light and power. Thoro and detailed discussion.

**Street Railway Journal.**

254. Vol. 14, p. 775. Electrolysis fallacies, by A. B. Herrick.

**Water and Gas Review.**

255. 1895, Feb., p. 15. Thoro discussion of electrolysis troubles at Brooklyn, N. Y., by J. A. Barrett.

256. 1895, Aug., p. 14. Thoro illustrated discussion of electrolysis at Boston, Mass., by Stone and Webster.

257. 1898, Oct., p. 13. Report of electrolysis damages at Dayton, Ohio, by H. P. Brown.

258. 1899, Nov., p. 25. Symposium of electrolysis troubles in various towns.

259. 1901, March, p. 22. Copy of ordinance to prevent electrolysis at Battle Creek, Mich.

260. 1905, Sept., p. 14. Thoro legal discussion of liability of water companies for fire losses, cites many cases covering all phases of subject, by H. M. Kales.

**Wisconsin Gas Association.**

261. 1908, p. 16. Brief, but pointed, discussion of depreciation, by E. S. Mack.

**Western Society of Engineers.**

262. Vol. 6, p. 529. Brief, but pointed, discussion of electrolysis, by E. B. Ellicott.

263. Vol. 17, p. 147. Thoro discussion of going value, by F. F. Fowle.

**Western Gas Association.**

264. 1901, p. 395. Classified bibliography of references pertaining to gas engineering.

265. 1902, p. 512. Brief discussion of electrolysis of underground metals, by J. M. Humiston.

## UNITED STATES GOVERNMENT PUBLICATIONS.

266. Bureau of the Census. Bulletin on Uniform Accounts for Systems of Water Supply.

267. Bureau of the Census. Bulletin 21, Commercial Valuation of Railway Operating Property in the United States.

268. Bureau of the Census. Special Report on Electric Street Railways, 1907.

269. Bureau of the Census. Special Report on Central Electric Light and Power Stations, 1907.

270. Bureau of the Census. Special Report on Telephones, 1907.

271. Bureau of Labor. Bulletin No. 93, March, 1911, Data on prices from 1890 to 1910.

272. Bureau of Corporations. Report on Water Power Development in the United States.
Gives valuable data.

273. Bureau of Entomology. Bulletin No. 94, Part 1.
Thoro discussion of damage done to telephone and telegraph poles by wood boring insects, by T. E. Snyder.

274. Bureau of Plant Industry. Bulletin No. 64.
Methods of destroying or preventing the growth of algae and certain pathogenic bacteria in water supplies, by George T. Moore and Karl F. Kellerman.

275. Bureau of Plant Industry. Bulletin No. 76.
Copper as an algicide and disinfectant in water supplies, by George T. Moore and Karl F. Kellerman.
Gives results obtained in a large number of applications.

276. Interstate Commerce Commission Statistics of Railways. Vol. 23, p. 38.
Average daily compensation of railway employes from 1900 to 1910.

277. Interstate Commerce Commission, Accounting Series, Circular 13.
Discussion of insurance method of providing for depreciation.

278. Report of the Railroad Securities Commission, Document No. 256, House of Representatives.
Thoro discussion of railroad securities.

279. U. S. Department of Agriculture, Forest Service, Circular No. 128.
Thoro and illustrated discussion of preservation of piling against marine wood borers, by C. S. Smith.

280. U. S. Department of Agriculture, Year Book, 1902, p. 175.
Brief, but pointed, discussion of contamination of public water supplies by algae, by George T. Moore.

| | | | | |
|---|---|---|---|---|
| 281. | 3 | Dallas, | p. 390, | Calder v. Bull. |
| 282. | 4 | Wheaton, | p. 316, | M. Culloch v. Maryland. |
| 283. | 4 | " | p. 518, | Dartmouth College v. Woodward. |
| 284. | 4 | " | p. 581, | " " " " |
| 285. | 6 | " | p. 330, | Cohens v. Virginia. |
| 286. | 6 | " | p. 404, | " " " |
| 287. | 6 | " | p. 413, | " " " |
| 288. | 9 | " | p. 196, | Gibbons v. Ogden. |
| 289. | 11 | Peters, | p. 420, | Charles River Bridge v. Warren Bridge. |
| 290. | 5 | Howard, | p. 583, | License Cases. |
| 291. | 6 | " | p. 507, | West River Bridge Co. v. Dix. |
| 292. | 6 | " | p. 531, | " " " " " " |
| 293. | 6 | " | pp. 532-3, | " " " " " " |
| 294. | 13 | " | p. 81, | R. F. & P. Ry. Co. v. L. Ry. Co. |
| 295. | 18 | " | p. 276, | Murray's Lessee v. H. L. & I. Co. |
| 296. | 21 | " | p. 506, | Ableman v. Booth. |
| 297. | 23 | " | p. 66, | D. & P. Ry. Co. v. Litchfield. |
| 298. | 1 | Black, | p. 358, | Rice v. Railroad Co. |
| 299. | 1 | Wallace, | p. 206, | Gelpcke v. Dubuque. |
| 300. | 3 | " | p. 73, | The Binghamton Bridge. |
| 301. | 3 | " | p. 725, | Gilman v. Philadelphia. |
| 302. | 10 | " | p. 51, | People's Ry. Co. v. Memphis City Ry. Co. |
| 303. | 12 | " | p. 531, | Legal Tender Cases. |
| 304. | 13 | Wallace, | p. 397, | Tarble's Case. |
| 305. | 16 | " | p. 67, | Slaughter Cases. |
| 306. | 23 | " | p. 108, | Secombe v. Ry. Co. |
| 307. | 94 | U. S. | p. 113, | Munn v. Illinois. |
| 308. | 94 | " | p. 123, | " " " |
| 309. | 94 | " | p. 124, | " " " |
| 310. | 94 | " | p. 125, | " " " |
| 311. | 94 | " | p. 126, | " " " |
| 312. | 94 | " | p. 127, | " " " |
| 313. | 94 | " | p. 130, | " " " |
| 314. | 94 | " | p. 133, | " " " |
| 315. | 94 | " | p. 134, | " " " |
| 316. | 94 | " | p. 162, | " " " |
| 317. | 94 | " | p. 165, | " " " |
| 318. | 96 | " | p. 63, | Turnpike Co. v. Illinois. |
| 319. | 96 | " | p. 101, | Davidson v. New Orleans. |
| 320. | 96 | " | p. 521, | Railroad Co. v. Richmond. |
| 321. | 97 | " | p. 25, | Beer Co. v. Massachusetts. |
| 322. | 97 | " | p. 659, | Fertilizer Co. v. Hyde Park. |
| 323. | 97 | " | p. 666, | " " " " " |
| 324. | 98 | " | p. 407, | Boom Co. v. Patterson. |
| 325. | 99 | " | p. 402, | Union Pac. Ry. v. United States. |
| 326. | 99 | " | p. 747, | Sinking Fund Cases. |
| 327. | 99 | " | p. 761, | " " " |

| | | | | |
|---|---|---|---|---|
| 328. | 100 | U. S. | p. 346, | Ex parte Virginia. |
| 329. | 101 | " | p. 71, | Thomas v. Railroad Co. |
| 330. | 101 | " | p. 794, | Wright v. Nagle. |
| 331. | 101 | " | p. 796, | " " " |
| 332. | 101 | " | p. 816, | Stone v. Mississippi. |
| 333. | 101 | " | p. 817, | " " " |
| 334. | 101 | " | p. 820, | " " " |
| 335. | 108 | " | p. 527, | Ruggles v. Illinois. |
| 336. | 109 | " | p. 13, | Civil Rights Cases. |
| 337. | 110 | " | p. 354, | Spring Valley W. W. v. Schottler. |
| 338. | 110 | " | p. 682, | A. D. & S. Ry. v. D. & N. O. Ry. |
| 339. | 111 | " | p. 437, | Slidell v. Grandjean. |
| 340. | 111 | " | p. 438, | " " " |
| 341. | 111 | " | p. 746, | Butchers' Union v. Crescent City, etc. |
| 342. | 113 | " | p. 710, | Soon Hing v. Crowley. |
| 343. | 115 | " | p. 512, | M. P. Ry. v. Humes. |
| 344. | 115 | " | p. 650, | New Orleans Gas Co. v. Louisiana L. Co |
| 345. | 115 | " | p. 673, | " " " " " " " |
| 346. | 116 | " | p. 307, | Railroad Commission Cases. |
| 347. | 116 | " | p. 331, | " " " |
| 348. | 118 | " | p. 356, | Yick Wo v. Hopkins, Sheriff. |
| 349. | 118 | " | p. 569, | Wabash Ry. Co. v. Illinois. |
| 350. | 119 | " | p. 265, | New Orleans v. Houston. |
| 351. | 125 | " | p. 18, | New Orleans W. W. Co. v. L. S. R. Co. |
| 352. | 125 | " | p. 31, | New Orleans W. W. Co. v. L. S. R. Co. |
| 353. | 125 | " | p. 181, | Pembina Con. Mining Co. v. Penna |
| 354. | 125 | " | p. 188, | " " " " " " |
| 355. | 125 | " | p. 260, | Hannibal R. R. v. Missouri P. Ry. |
| 356. | 125 | " | p. 686, | Dow v. Beidelman. |
| 357. | 127 | " | p. 40, | California v. C. P. Ry. |
| 358. | 127 | " | p. 205, | Missouri P. Ry. v. Mackey. |
| 359. | 129 | " | p. 26, | M. & St. L. Ry. v. Beckwith. |
| 360. | 130 | " | p. 26, | Oregon Ry. Co. v. Oregonian Ry. Co. |
| 361. | 133 | " | p. 170, | Farmers' L. & T. Co. v. Galesburg. |
| 362. | 134 | " | p. 456, | C. M. & St. P. Ry. v. Minnesota. |
| 363. | 134 | " | p. 458, | " " " |
| 364. | 134 | " | p. 459, | " " " |
| 365. | 137 | " | p. 692, | Caldwell v. Texas. |
| 366. | 138 | " | p. 287, | Wheeling & B. B. Co. v. W. B. Co. |
| 367. | 139 | " | p. 24, | Central Transportation Co. v. Pullman Co. |
| 368. | 141 | " | p. 67, | Stein v. Bienville W. S. Co. |
| 369. | 141 | " | p. 80, | " " " |
| 370. | 142 | " | p. 386, | C. C. & A. Ry. v. Gibbes. |
| 371. | 143 | " | p. 344, | C. & G. T. Ry. v. Wellman. |
| 372. | 143 | " | p. 457, | Holy Trinity Church. |
| 373. | 143 | " | p. 547, | Budd v. New York. |
| 374. | 144 | " | p. 562. | Coosaw M. Co. v. S. Carolina. |
| 372. | 143 | " | p. 457, | New York Elec. Lines v. Squire. |
| 376. | 146 | " | p. 258, | Hamilton G. L. & C. Co. v. Hamilton. |
| 377. | 146 | " | p. 260, | " " " |
| 378. | 146 | " | p. 268, | " " " |
| 379. | 148 | " | p. 328, | Monongahela N. Co. v. U. S. |

| | | | | |
|---|---|---|---|---|
| 380. | 148 | U. S. | p. 345, | Monongahela N. Co. v. U. S. |
| 381. | 149 | " | p. 364, | M. & St. L. Ry. v. Emmons. |
| 382. | 149 | " | p. 367, | " " " |
| 383. | 149 | " | p. 608, | Byers v. McAuley. |
| 384. | 151 | " | p. 481, | Columbus S. Ry. v. Wright. |
| 385. | 151 | " | p. 556, | N. Y. & N. E. Ry. v. Bristol. |
| 386. | 152 | " | p. 133, | Lawton v. Steele. |
| 387. | 152 | " | p. 137, | " " " |
| 388. | 153 | " | p. 424, | New Orleans v. Benjamin. |
| 389. | 153 | " | p. 436, | Ashley v. Ryan. |
| 390. | 154 | " | p. 390, | Regan v. Farmers' Loan Co. |
| 391. | 154 | " | p. 393, | " " " |
| 392. | 154 | " | p. 395, | " " " |
| 393. | 154 | " | p. 397, | " " " |
| 394. | 154 | " | p. 399, | " " " |
| 395. | 154 | " | p. 412, | " " " |
| 396. | 154 | " | p. 445, | Railway Co. v. Backus. |
| 397. | 155 | " | p. 652, | Hooper v. California. |
| 398. | 155 | " | p. 658, | " " " |
| 399. | 156 | " | p. 657, | St. L. & S. F. R. v. Gill. |
| 400. | 156 | " | p. 663, | " " " |
| 401. | 158 | " | p. 99, | Gulf, Colorado, etc., Ry. v. Hefley. |
| 402. | 158 | " | p. 590, | In re Debs. |
| 403. | 159 | " | p. 660, | Lambert v. Barrett. |
| 404. | 161 | " | p. 648, | Pearsall v. G. N. Ry. |
| 405. | 161 | " | p. 660, | " " " |
| 406. | 161 | " | p. 661, | " " " |
| 407. | 161 | " | p. 664, | " " " |
| 408. | 161 | " | p. 673, | " " " |
| 409. | 162 | " | p. 184, | C. N. O. & T. P. Ry. v. I. C. C. |
| 410. | 164 | " | p. 327, | Central Ry. Co. v. Wright. |
| 411. | 164 | " | p. 592, | Covington & L. T. Co. v. Sandford. |
| 412. | 164 | " | p. 596, | " " |
| 413. | 164 | " | p. 597, | " " |
| 414. | 165 | " | p. 1, | St. L. & S. F. v. Mathews. |
| 415. | 165 | " | p. 579, | Allgeyer v. Louisiana. |
| 416. | 166 | " | p. 290, | U. S. v. T. M. F. Assoc. |
| 417. | 166 | " | p. 430, | Gladson v. Minnesota. |
| 418. | 166 | " | p. 562, | City Railway Co. v. Citizens' Ry. Co. |
| 419. | 166 | " | p. 685, | Long Island Water Sup. Co. v. Brooklyn. |
| 420. | 166 | " | p. 689, | " " |
| 421. | 166 | " | p. 693, | " " |
| 422. | 167 | " | p. 633, | I. C. C. v. Detroit, etc. |
| 423. | 168 | " | p. 145, | I. C. C. v. A. M. Ry. |
| 424. | 169 | " | p. 392, | Holden v. Hardy. |
| 425. | 169 | " | p. 467, | Smyth v. Ames. |
| 426. | 169 | " | p. 523, | " " " |
| 427. | 169 | " | p. 524, | " " " |
| 428. | 169 | " | p. 526, | " " " |
| 429. | 169 | " | p. 527, | " " " |
| 430. | 169 | " | p. 541, | " " " |
| 431. | 169 | " | p. 544, | " " " |

| | | | | |
|---|---|---|---|---|
| 432. | 169 | U. S. | p. 545, | Smyth v Ames. |
| 433. | 169 | " | p. 546, | " " " |
| 434. | 169 | " | p. 547, | " " " |
| 435. | 172 | " | p. 1, | Walla Walla v. Walla Walla Water Co. |
| 436. | 172 | " | p. 557, | Orient Insurance Co. v. Daggs. |
| 437. | 173 | " | p. 297, | L. S. & M. S. Ry. v. Ohio. |
| 438. | 173 | " | p. 684, | L. S. & M. S. Ry. v. Smith. |
| 439. | 173 | " | p. 689, | " " " |
| 440. | 173 | " | p. 690, | " " " |
| 441. | 173 | " | p. 691, | " " " |
| 442. | 173 | " | p. 697, | " " " |
| 443. | 174 | " | p. 96, | A. T. & S. F. Ry. v. Mathews. |
| 444. | 174 | " | p. 750, | San Diego Land Co. v. National City. |
| 445. | 174 | " | p. 757, | " " " |
| 446. | 175 | " | p. 348, | Tullis v. L. E. & W. Ry. |
| 447. | 175 | " | p. 649, | L. & M. Ry. v. Behlmer. |
| 448. | 176 | " | p. 172, | C. M. & S. P. v. Tompkins. |
| 449. | 176 | " | p. 173, | " " " |
| 450. | 176 | " | p. 174, | " " " |
| 451. | 176 | " | p. 203, | Dickerman v. Northern Trust Co. |
| 452. | 177 | " | p. 601, | Williams v. Wingo. |
| 453. | 178 | " | p. 321, | Wheeler v. N. Y., N. H. & H. Ry. Co. |
| 454. | 179 | " | p. 297, | W. M. & P. Ry. v. Jackson. |
| 455. | 181 | " | p. 100, | Western Union Telegraph Co. v. Call. |
| 456. | 181 | " | p. 101, | " " " |
| 457. | 181 | " | p. 148, | St. P. G. L. Co. v. St. Paul. |
| 458. | 183 | " | p. 95, | Cotting v. Kansas City S. Y. Co. |
| 459. | 183 | " | p. 102, | " " " |
| 460. | 184 | " | p. 382, | Detroit v. Detroit Citizens' St. Ry. Co. |
| 461. | 186 | " | p. 267, | Minneapolis & St. L. Ry. Co. v. Minnesota. |
| 462. | 189 | " | p. 439, | San D. L. & T. Co. v. Jasper. |
| 463. | 190 | " | p. 273, | I. C. C. v. L. & N. Ry. |
| 464. | 192 | " | p. 201, | Stanislaus County v. S. J. C. & I. Co. |
| 465. | 192 | " | p. 213, | " " " |
| 466. | 192 | " | p. 214, | " " " |
| 467. | 194 | " | p. 517, | Cleveland v. Cleveland City Ry. |
| 468. | 197 | " | p. 115, | National Cotton Oil Co. v. Texas. |
| 469. | 200 | " | p. 22, | Knoxville Water Co. v. Knoxville. |
| 470. | 200 | " | p. 58, | Guardian Trust Co. v. Fisher. |
| 471. | 206 | " | p. 508, | Vicksburg v. Vicksburg Water Co. |
| 472. | 209 | " | p. 124, | Ex parte Young. |
| 473. | 209 | " | p. 125, | " " |
| 474. | 209 | " | p. 143, | " " |
| 475. | 209 | " | p. 148, | " " |
| 476. | 211 | " | p. 54, | Berea College v. Kentucky. |
| 477. | 211 | " | p. 210, | Prentis v. Atlantic C. L. Ry. |
| 478. | 211 | " | p. 226, | " " " |
| 479. | 211 | " | p. 273, | Home Telephone Co. v. Los Angeles. |
| 480. | 212 | " | p. 1, | Knoxville v. Water Co. |
| 481. | 212 | " | p. 8, | " " " |
| 482. | 212 | " | p. 13, | " " " |
| 483. | 212 | " | p. 14, | " " " |

| | | | | |
|---|---|---|---|---|
| 484. | 212 | U. S. | p. 17, | Knoxville v. Water Co. |
| 485. | 212 | " | p. 18, | " " " |
| 486. | 212 | " | p. 40, | Willcox v. Consolidated Gas Co. |
| 487. | 212 | " | p. 41, | " " " |
| 488. | 212 | " | p. 48, | " " " |
| 489. | 212 | " | p. 49, | " " " |
| 490. | 212 | " | p. 50, | " " " |
| 491. | 212 | " | p. 51, | " " " |
| 492. | 212 | " | p. 52-54, | " " " |
| 493. | 212 | " | p. 419, | Louisiana R. R. Com. v. Cumberland Teleph. Co. |
| 494. | 215 | " | p. 430, | Minneapolis v. Street Ry. Co. |
| 495. | 216 | " | p. 65, | Pullman Co. v. Kansas. |
| 496. | 216 | " | p. 162, | Ludwig v. Western Union T. Co. |
| 497. | 218 | " | p. 180, | Omaha v. Omaha Water Co. |
| 498. | 218 | " | p. 192, | " " |
| 499. | 218 | " | p. 194, | " " |
| 500. | 218 | " | p. 195, | " " |
| 501. | 218 | " | p. 198, | " " |
| 502. | 218 | " | p. 202, | " " |
| 503. | 218 | " | p. 645, | Columbus v. Mercantile Trust Co. |
| 504. | 218 | " | p. 658, | " " |
| 505. | 218 | " | p. 659, | " " |
| 506. | 219. | " | p. 111, | Noble State Bank v. Haskell. |
| 507. | 221 | " | p. 229, | Oklahoma v. Kansas Natural Gas Co. |
| 508. | 221 | " | p. 361, | Wilson v. United States. |
| 509. | 221 | " | p. 362, | " " |
| 510. | 223 | " | p. 359, | Lincoln Gas Co. v. Lincoln. |

## UNITED STATES CIRCUIT COURT REPORTS.

| | | | | |
|---|---|---|---|---|
| 511. | 18 Fed. Rep. | | p. 397, | Santa Clara County v. S. P. Ry. |
| 512. | 62 | " | p. 865, | National Water Works Co. v. Kansas City. |
| 513. | 72 | " | p. 955, | New Memphis G. L. Co. vo. Memphis. |
| 514. | 74 | " | p. 79, | S. D. L. & T. Co. v. National City |
| 515. | 74 | " | p. 87, | " " |
| 516. | 87 | " | p. 577, | Milwaukee Elec. Ry. & L. Co. v. Milwaukee. |
| 517. | 114. | " | p. 561, | Chi. Union Trac. Co. v. State Board of Equalization. |
| 518. | 123. | " | p. 946, | L. & N. Ry. v. Brown. |
| 519. | 124 | " | p. 595, | Spring Valley W. W. v. San Francisco. |
| 520. | 124 | " | p. 599, | " " |
| 521. | 156 | " | p. 823, | Cumberland T & T. Co. v. R. R. Comm. |
| 522. | 161 | " | p. 993, | Georgia Ry. Co. v. R. R. Comm. of Ala. |
| 523. | 163 | " | p. 567, | S. J. & K. R. C. & I. Co. v. Stanislaus County. |
| 524. | 165 | " | p. 518, | Contra Costa W. Co. v. Oakland. |
| 525. | 165 | " | p. 667, | Spring Valley W. Co. v. San Francisco. |
| 526. | 165 | " | p. 684, | " " |
| 527. | 165 | " | p. 693, | " " |
| 528. | 165 | " | p. 698, | " " |
| 529. | 165 | " | p. 702, | " " |
| 530. | 165 | " | p. 703, | " " |
| 531. | 168 | " | p. 317, | St. Louis & S. F. R. Co. v. Hadley. |
| 532. | 170 | " | p. 726, | Southern P. Co. v. Bartine. |

533. 170 Fed. Rep. p. 727, Southern P. Co. v. Bartine.
534. 170 " p. 775, " "
535. 174 " p. 348, Venner Co. v. Urbana Water Works Co.
536. 174 " p. 742, City of Owensboro v. Cumberland T. & T. Co.
537. 174 " p. 764, German All. Ins. Co. v. Home W. S. Co.
538. 177 " p. 493, Missouri K. & T. Ry. v .Love.
539. 177 " p. 496, " "
540. 181 " p. 997, Peoria Water W. Co. v. Peoria Ry. Co.
541. 181 " p. 998, " "
542. 181 " p. 1003, " "
543. 181 " p. 1004, " "
544. 181 " p. 1008, " "
545. 181 " p. 1010, " "
546. 182 " p. 926, Lincoln Gas & Elec. Co. v. Lincoln.
547. 184 " p. 766, Shepard v. N. P. Ry.
548. 184 " p. 769, " "
549. 184 " p. 770, " "
550. 184 " p. 772, " "
551. 184 " p. 781, " "
552. 184 " p. 806, " "
553. 184 " p. 809, " "
554. 184 " p. 815, " "
555. 186 " p. 189, L. & M. Ry. v Siler
556. 187 " p. 346, In re Arkansas Rate Cases.
557. 187 " p. 658, Cumberland T. & T. Co. v. Louisville.
558. 192 " p. 138, Spring V. W. W. v. San Francisco.
559. 192 " p. 192, " "
560. 192 " p. 198, Des Moines Water Co. v. Des Moines.
561. 194 " p. 216, Minneapolis G. E. Co. v. Minneapolis.

## STATE COURT REPORTS.

562. 82 Calif. p. 316, Water Works v. San Francisco.
563. 118 " p. 637. San Diego Water Co. v. San Diego.
564. 76 Conn. p. 566, N. G. & E Co. v. Norwich.
565. 74 Kan. p. 736, Galena Water Co. v. Galena.
566. 100 Ky. p. 408, Louisville Gas Co. v. Dulany, etc.
567. 97 Maine p. 185, Kennebec Water Dist. v. Waterville.
568. 97 " p. 187, " "
569 97 " p. 188, " "
570. 99 " p. 372, Brunswick & T. Water Dist. v. Maine Water Co.
571. 99 " p. 373, " " " " " " "
572. 179 Mass. p. 367, Gloucester W. S. Co. v. Gloucester.
573. 52 Mich. p. 499, Williams v. Mutual Gas Co.
574. 52 " p. 503, " "
575. 69 Minn. p. 373, Steenerson v. Great Northern Ry.
576. 69 " p. 415, " "
577. 69 " p. 719, " "
578. 11 Mo. App. p. 55, St. Louis G. L. Co. v. St. Louis.
579. 34 " p. 501, Missouri v. Sedalia G. L. Co.
580. 76 " p. 540, Carney v. Chillicothe W. & L. Co.
581 84 Mo. p. 202, St. Louis G. L. Co. v. St. Louis.
582. 235 " p. 551, Home Telephone Co. v. Carthage.

583. 67 N. J. Eq. p. 123, P. S. Co. v. Am. L. Co.
584. 70 " p. 71, Long Branch v. Tintern Manor Water Co.
585. 70 " p. 482, " "
586. 91 N. W. p. 1091, Cedar Rapids Water Co. v. Cedar Rapids.
587. 120 " p. 966, Cedar Rapids G. L. Co. v. Cedar Rapids.
588. 120 " p 974, " "
589. 122 N. Y. (App. Div.) p. 219, Saratoga Sprgs. v. Saratoga G. Elec., etc.
590. 135 N. Y. p. 407, H. R. T. Co. v. W. T. & R. Co.
591. 196 " p. 58, Jamaica Water Sup. Co. v. Tax Commissioners.
592 203 " p. 235, Manhattan Ry. Co. v. Woodbury.
593. 60 N. Y. Supp. p. 561, Gould v. Edison E. I. Co.
594. 60 " p. 562, " "
595. 112 " p. 395, People v. Board of Tax Commissioners.
596. 26 Ohio C. C. R. p. 736, Dayton v. City Ry. Co.
597. 113. Pac. p. 668, Contra Costa Water Co. v. Oakland.
598. 113 " p. 671, " "
599. 117 " p. 748, Puget Sound E. Ry. v. Railroad Commission.
600. 118 " p. 354, Pioneer Telephone & T. Co. v. Westenhaver.
601. 118 " p. 358, " "
602. 118 " p. 360, " "
603. 118 " p. 363, " "
604. 118 " p. 365, " "
605. 119 " p. 317, Cunningham v. Iola.
606. 172. Pa. p. 489, Brymer v. Butler Water Co.
607. 179 " p. 251, " "
608. 179 " p. 252, " "
609. 220 " p. 115, Pennsylvania Ry. Co. v. Philadelphia County.
610 23 R. I. p. 278, Bristol v. Bristol W. W.
611. 42 S. W. p. 351, Owensboro G. L. Co. v. Hildebrand.
612. 52 " p. 609, State v. F. Fund Ins. Co.
613. 53 " p. 996, Harbison v. Knoxville Water Co.
614. 137 " p. 1097, Arkadelphia Elec. L. Co. v. Arkadelphia.
615. 93 Tenn. p. 503, T. & T. Co. v. Elec. Ry. Co.
616. 93 " p. 511, " "
617. Tenn. Chancery Case No. 8368, Chavaunes v. Knoxville W. Co. Affirmed by State Supreme Court, but not reported.
618. 3 Wash. p. 316, Tacoma H. Co. v. T. L. & W. Co.
619. 6 Wis. p. 548, Shepard v. Milwaukee G. L. Co.

## BRITISH CHANCERY APPEAL CASES.

620. 6 Ch. p. 104, Rance's Case.
621. 10 " p. 118, National Funds Assurance Co.
622. 35 " p. 502, Oxford Benefit Building Society.
623. 36 " p. 787, Leeds Estate Company v. Shepherd.

## INTERSTATE COMMERCE COMMISSION REPORTS.

624. 1 I. C. C. Rep. p. 31, Petition of L. & N. Ry.
625. 1 " p. 107, Providence Coal Co. v. P. & W. Ry.
626. 1. " p. 436, Boston Cham. of Com. v. L. S. & M. S. Ry.

627. 2. I. C. C. Rep. p. 90, Schofield v. L. S. & M. S. Ry.
628. 2. " p. 147, Lincoln Board of Trade v. B. & M. P. Ry.
629. 2 " p. 252, B. M. A. of S. M. v. C. N. W. Ry.
630. 2 " p. 272, N. W. Howell v. N. Y., L. E. & W. Ry.
631. 2 " p. 618, Imperial Coal Co. v. P. & L. E. Ry.
632. 3 " p. 225, Abbott v. East T., Va. & Ga. Ry.
633. 3 " p. 473, Thurber v. N. Y. C. & H. R. Ry.
634. 4 " p. 1, Lehmann H. & Co. v. S. P. Ry.
635. 4 " p. 32, Warner v. N. Y. C. & H. R. Ry.
636. 4 " p. 41, Andrews Soap Co. v. P. C. & St. L. Ry.
637. 4 " p. 87, Procter & Gamble v. C. H. & D. Ry.
638. 5 " p. 264, Eau Claire B. of T. v. C. M. & St. P. Ry.
639. 5 " p. 529, Loud v. S. C. Ry.
640. 6 " p. 121, Morrell v. U. P. Ry.
641. 6 " p. 195, Chicago F. B. v. L. N. A. & C. Ry.
642. 6 " p. 257, Behlmer v. M. & C. Ry.
643. 6 " p. 488, Colorado F. & I. Co. v. S. P. Ry.
644. 7 " p. 43, Rea v. M. & O. Ry.
645. 7 " p. 180, Cinti. C. of C. v. C. N. O. & T. P. Ry.
646. 8 " p. 158, Grain Shippers' Assoc. v. I. C. Ry.
647. 8 " p. 346, Tileston Milling Co. v. N. P. Ry.
648. 8 " p. 503, Hampton B. of T. v. N. C. & St. L. Ry.
649. 9 " p. 264, National Hay Assoc. v. L. S. & M. S. Ry.
650. 9 " p. 382, Proposed Advances in Freight Rates.
651. 9 " p. 534, Mayor & Council of Wichita v. A. T. & S. F. Ry.
652. 10 " p. 327, New Orleans L. S. E. v. T. & P. Ry.
653. 10 " p. 412, Wrigley v. C. C. C. & St. L. Ry.
654. 10 " p. 505, Cent. Y. P. Assoc. v. I. C. Ry.
655. 11 " p. 271, Class and Commodity Rates.
656. 11 " p. 640, Farrar Lumber Co. v. S. Ry.
657. 12 " p. 215, Stowe-Fuller Co. v. Penn. Ry.
658. 15 " p. 417, Spokane v. Northern P. Ry.
659. 20 " p. 344, Western Advanced Rate Case.

## INDIANA RAILROAD COMMISSION REPORTS.

660. Case No. 495, Jan., 1912. Matter of Local Merchandise Rates.

## MASSACHUSETTS GAS AND ELECTRIC LIGHT COMMISSION REPORTS.

661. Vol. 4, p. 77, Newton petition.
662. " 5, p. 3, Preface to Report.
663. " 5, p. 92, Wakefield Matter.
664. " 5, p. 95, Clinton Gas Light Co. v. Merchants' Elec. Co.
665. " 5, p. 101, Roxbury Elec. Light Co. Appeal.
666. " 5, p. 106, Middleborough E. L. & P. Co. v. M. Gas & E. Co.
667. " 7, p. 17, Methuen matter.
668. " 9, p. 24, Worcester Elec. Light Co. Appeal.
669. " 10, p. 8, Chelsea Gas Light Co. Appeal.
670. " 10, p. 17, Boston Appeal.
671. " 10, p. 19, Great Barrington Appeal.
672. " 19, p. 24, Haverhill Appeal.
673. " 23, p. 26, Ripon "
674. " 23, p. 32, Easthampton Appeal.
675. " 25, p. 31, Rates for Boston School Committee.

## NEW JERSEY PUBLIC UTILITY COMMISSION REPORTS.

676. May 31, 1911, Highlands Gas Co. Ordinance.
677. Jan. 16, 1912, Minimum monthly charge matter.

## NEW YORK PUBLIC SERVICE COMMISSION REPORTS.

### First District.

678. Vol. 1, 1908, p. 177, Indeterminate Franchises.
679. Vol. 2, 1908, p. 704, Breakdown Service.
680. Vol. 2, 1908, pp. 145-152, Thoro discussion of fallacy of competition.
681. Vol. 2, 1909, p. 447, Specifications for Electric Meters.
682. Vol. 3, 1909, p. 22, Relation of increase of street railway traffic to increase of population.
683. June 23, 1911, Gas and Electric rates charged by Queens Borough Gas and Electric Co.
684. Oct. 20, 1911, John G. Mayhew v. Kings County Lt. Co.
685. Vol. 3, 1912, p. 301, Gas Pressure Conditions.

### Second District.

686. Vol. 1, 1908, p. 177, Rochester, Corning, Elmira Traction Co.
687. Vol. 2, 1910, p. 489, Genesee Light & Power Co.

## WISCONSIN RAILROAD COMMISSION REPORTS.

688. 2 W. R. C. p. 3, In re app. LaCrosse Gas and Elec. Co.
689. 2 " p. 308, In re Milwaukee Central Heating Co.
690. 2 " p. 632, Standards for Gas and Electric Service.
691. 3 " p. 67, Valuation of Cashton Light and Power Co.
692. 3 " p. 138, Investigation Hudson Water Works.
693. 3 " p. 623, Hill v. Antigo Water Co.
694. 3 " p. 706, " "
695. 3 " p. 707, " "
696. 3 " p. 709, " "
697. 3 " p. 711, " "
698. 3 " p. 778, Valuation Menominee and Marinette L. & T. Co.
699. 3 " p. 831, " "
700. 3 " p. 877, " " " "
701. 3 " p. 898, " " " "
702. 4 " p. 1, Payne v. Wisconsin Telephone Co.
703. 4 " p. 60, " "
704. 4 " p. 89, In re North Milwaukee L. & P. Co.
705. 4 " p. 99, " " " "
706. 4 " p. 150, Berend v. Wisconsin Telephone Co.
707. 4 " p. 226, In re Cumberland M. El. L. P.
708. 4 " p. 273, Ashland v. Ashland Water Co.
709. 4 " p. 292, " "
710. 4 " p. 501, State Journal Printing Co. v. Madison G. & E. Lt. Co.
711. 4 " p. 559, " " "
712. 4 " p. 601, " " "
713. 4 " p. 626, " " "
714. 4 " p. 649, " " "
715. 5 " p. 1, Ripon v. Ripon Light and Water Co.
716. 5 " p. 33, " "
717. 5 " p. 101, In re Green Bay Gas and Electric Co.

| | | | | |
|---|---|---|---|---|
| 718. | 5 | W. R. C. | p. 162, | Ross v. Burkhardt M. & E. P. Co. |
| 719. | 5 | " | p. 215, | Appleton v. Appleton Water Works Co. |
| 720. | 5 | " | p. 370, | Manitowoc v. Manitowoc W. and E. L. Co. |
| 721. | 5 | " | p. 383, | " " |
| 722. | 5 | " | p. 384, | " " |
| 723. | 5 | " | p. 397, | Darlington E. L. and W. P. Co. |
| 724. | 5 | " | p. 482, | Valuation Fond du Lac Water Co. |
| 725. | 5 | " | p. 555, | In re Jefferson Municipal E. L. and W. P. |
| 726. | 5 | " | p. 560, | " " " " |
| 727. | 5 | " | p. 691, | " Oconto City Water Supply Co. |
| 728. | 5 | " | p. 693, | " " " " |
| 729. | 6 | " | p. 157, | Whitewater v. Whitewater El. L. Co. |
| 730. | 6 | " | p. 371, | Sheboygan v. Sheboygan Ry. & El. Co. |
| 731. | 7 | " | p. 71, | In re Manitowoc Water Works Co. |
| 732. | 8 | " | p. 119, | Kenosha Elec. Ry. Co. v. K. G. and E. Co. |
| 733. | 8 | " | p. 617, | Waupaca E. L. and Ry. matter. |
| 734. | 9 | " | p. 250, | Beloit W. G. & E. Co. v. Beloit. |

By necessity, by proclivity and by delight we all quote. Next to the originator of a good sentence, is the first quoter o it.
—R. W. Emerson.

# Name or Authorities' Index


**Abbott, A. C.**
Asiatic cholera and water supplies, 812.

**Allen, Walter S.**
Cost of rate wars, 92.

**Alvord, J. W.**
Going Value:
Physical property cost no criterion of, 543.
Service cost no criterion of, 542.

**Baxter, Sylvester,**
Regulation of monopolies, 85.

**Brannon, Henry,**
Limitation of rate regulation power, 230.
Definition of property, 222.
Square deal for all insured by 14th amendment, 223.
Test for vested right, 238.

**Byllesby, H. M.**
Economic importance of capitalist, 126.
Engineering estimates usually low, 489.
Intangible property must be valued, 480.
Mobility of capital, 125.

**Carter, James C.**
Legislative expedients, 20.

**Choate, C. F., Jr.**
What riparian rights include, 525.

**Deiser, G. F.**
Electrolysis before the courts, 450.

**Doherty, Henry L.**
Unprofitable rates are discriminatory, 575.

**Ellicott, E. B.**
Electrolysis current paths in earth, 409.

**Ellis, David,**
Bacteria belong to vegetable kingdom, 804.
Bacteria, what are, 802.

**Floy, Henry,**
Commercial limitation of equipment life, 319.
Depreciation:
Maintenance and, 327.
Gross earnings basis method, 368.
Functional, 320.
Inadequacy, 321.
Obsolescence, 322.
Scrap or junk value defined, 64.
Service value defined, 67.
Useful life of engineering structures, Table 8, p. 244.
What caused demand for regulation, 16.

**Fowle, F. F.**
Unprofitable rates are discriminatory, 575.

**Frost, W. D.**
Classes of bacteria found in water, 805.


(Numbers refer to sections unless otherwise indicated.)

**Ganz, Prof. Albert F.**
Electrolysis:
Complete remedy for, 417.
Corrosive tendencies of cast iron, wrot iron and steel, 404.
Current carrying tendencies of cast iron, wrot iron and steel, 405.
Damages caused by return on other Utility structures, 434.
Dangers in return on other Utility structures, 433.
Electric current determination, 412.
Electric current must be known, 411.
Electrolysis may cause secondary corrosion, 446.
Electrolyte, what is, 388.
Elimination of electrolysis, 416.
Fire hazard due to electrolysis, 447.
Nature of corrosion of cast iron, 414.
Nature of corrosion of wrot iorn and steel, 413.
Negligible stray current sources, 382.
Pure water is non-conductor, 387.
Radial return system, proper copper distribution, 431.
Radial return system requirements, 430.
Rate of electrolytic corrosion, 403.
Return on other Utility structures, 432.
Stray currents, 381.
Use of underground structures of other Utilities is saving to electric railway, 436.
Voltage no criterion in electrolysis, 410.

**Gillette, H. P.**
Valuation:
How reproduction cost is ascertained, 473.

**Glass, S. J.**
Prices of artificial gas in 172 towns, 99.

**Gray, John Chipman,**
Conflict of natural and human law, 82.
Public opinion and custom, 6.

**Grunsky, C. E.**
Correct valuation basis for rate making, 560.
Distinction between replacement and amortization, 31.

**Hadley, Arthur T.**
Cost defined, 40.
Fallacy of competition, 88.
Relation of quantity and price, 135.

**Hammond, M. B.**
Competition as a regulator of rates, 627.
Extra service justifies higher rates, 607.
Test for freight rate competition, 626.

**Harper, R. B.**
Summary of coating situation, 439.
Temperature, effect of, on electrolysis, 401.

**Harrison, F. C.**
Natural water bacteria, 806.
Soil bacteria from surface washings, 807.

**Hayden, J. L. R.**
Relation of electrolyte to electrolysis, 441.
Relation of frequency to corrosion, 443.
Relative alternating current electrolytic activities of lead and iron, 442.
Relative electrolytic activity of alternating and direct current, 440.
Temperature, effect of, on electrolysis, 401.

**Hazen, Allen,**
Coagulation of water, 775.
Iron in water supplies, 800.
Percentage of iron that will give trouble in water supplies, 801.
Water, color, 784.

(Numbers refer to sections unless otherwise indicated.)

**Hill, James J.**

Fair profits and reasonable rates, 11.
Regulative standards, 18.
Supremacy of natural laws, 81.

**Hill, N. S., Jr.**

Animal growths in water mains, 345.
Tuberculation of water mains, 343.

**Hiss, P. H.**

Asiatic cholera, 812.
Bacteria, number present, 814.
Colon bacillus, 808.
Dysentery bacillus, 811.

**Hitchcock, Prof. E. A.**

Locomotive fuel losses, 101.

**Hodgman, B. B.**

Water main cleaning, results of, 346.

**Horton, R. E.**

Criterion for stream diversion damages, 524.
Present worth of undeveloped water powers, 111.
Water power rights must be valued alone, 528.

**Humiston, J. M.**

Soil constituents in electrolysis, 399.

**Humphreys, A. C.**

True average or composite life, 374.

**Hutchins, F. L.**

Economic limit of maximum rate, 140.

**Interstate Commerce Commission.**

Advantage of natural location must not be discriminated against, 624.
Classification a duty of Utilities, 567.
Classification of charges:
Always a compromise, 569.
Criterion for, 570.
Competition, as a regulator of rates, 627.
Cost of freight service:
Cannot be accurately apportioned, 606.
Comparisons not safe, 608.
Less in car loads, 609.
Minimum charge justified, 611.
Not sole criterion, 605.
Discount based on mere quantity is inequitable, 589.
Distance,
Cost per mile does not necessarily increase with, 615.
Increase must generally be considered, 617.
Not always controlling, 614.
Rates not proportioned to, 616.
Fallacy of comparative statistics on rates, 565.
How Utility labor cost has increased, 98.
Insurance method for depreciation, 371.
Natural advantage of location,
Must be recognized, 622.
Must not be neutralized, 623.
One rate cannot be considered by itself, 628.
Profit included in reasonable rate, 632.
Rate,
May not be increased merely because land values have increased, 515.
Risk as an element of freight rate, 612.

(Numbers refer to sections unless otherwise indicated.)

Ton-mile,
No test for local rates, 620.
Status of, 619.
Value of commodity.
Advertising description determines class, 600.
And transportation rate, 599.
Freight rate must bear some relation to, 604.
Not only test for freight rate, 602.
Relation to carriers' liability, 601.
When freight rate may fluctuate with, 603.

**Indiana Railroad Commission.**
Valuation, purpose of, 468.

**Jackson, D. C.**
Electrolysis of water not cause of corrosion, 390.
Fair attitude toward Utilities, 25.
Rates, cardinal principles of, 26.
Voltage in electrolysis, 410.

**Jordon, Edwin O.**
Paratyphoid bacillus, 809.

**Joyce, Joseph A. and Howard C.**
Conduction, 765.
Induction, 766.
McCluer device, 764.

**Kinkaid, E. B.**
Common law, definition of, 19.

**Knudson, A. A.**
Dangers from bonded cable sheaths, 435.
Electrolysis of iron and steel in concrete, 444.
Railway return, 395.

**Kellerman, Karl F.**
Algae growths in water supplies, 342.

**Lampher, E. E.**
Coating or painting of mains, 438.

**Leake, P. D.**
Depreciation allowance is for past obligations, 316.

**Leffmann, Henry.**
Oxygen consuming capacity of water, 788.

**Macleod, H. D.**
Alteration in value and depreciation distinguished, 34.
Property, definition of, 39.
Value, definition of, 59.

**Main, C. T.**
Value of a water power, 107.

**Massachusetts Gas and Electric Light Commission,**
Competition, failure of, 91.
Reductions in rates based on mere quantity are wrong, 587.

**Mason, W. P.**
Algae growths in water supplies, 342.
Water, permanent hardness of, 795.
Water, analysis, significance of, 783.
Water, temporary hardness of, 796.

**MacNutt, J. S.**
Water supply and death rate, 154.

**Maury, D. H.**
Fire hydrant service, 152.

**McCampbell, E. F.**
Classes of bacteria found in water, 805.

(Numbers refer to sections unless otherwise indicated.)

**McCullum, Burton,**
Coating or painting of mains, 438.
Electrolysis, difficulties of, 383.
Joint resistance, 437.
Pipe resistance, 407.

**McGehee, L. P.**
Due process of law, 224.

**McGowan, H. E.**
Complete remedy for electrolysis, 417.

**Metcalf, Leonard,**
Useful life of engineering structures, Table 7, p. 243.

**Meyer, B. H.**
Scope of Interstate Commerce Commission decisions, 598.

**Meyers, W. J.**
How rates for Utility securities are determined, 533.
Requirements of capitalization rate determination, 532.

**Montfort, R.**
Wood parasites, 333.

**Moore, G. T.**
Algae growths in water supplies, 342.

**Muir, Robert,**
Distinction between bacteria, germs and microbes, 803.

**Nagle, A. F.**
Limiting value of ample water power, 108.
Saving effected by water, 110.
Value insufficient water power, 109.
Water power, commercial value of, 104.
Water power, rights must be valued alone, 528.

**National Civic Federation,**
Failure of competition, 91.

**New Jersey Public Utility Commission,**
Failure of competition, 91.
Monthly basis for minimum charge best, 596.

**Newman, Bishop John P.**
Law, mission of, 20.
Liberty, limits of, 22.
Regulation, source of, 19.

**New York Public Service Commission,**
Amount land needed, 512.
Basis of land value, 514.
Break-down service defined, 77.
Factors affecting gas pressures, 678.
Failure of competition, 91.
Fallacy of competition, 88.
Going value distinguished from going concern value, 556.
Going value must be considered in rate cases, 548.
Intangible property must be valued, 480.
Maximum gas pressure, 680.
Minimum gas pressure, 679.
Population increase and street car traffic, 145.
Promotion cost must be considered, 481.
Sinking fund depreciation method, 364.
Standards for interest rates, 130.
Valuation,
Land, amount needed, 512.
Land, basis of value, 514.
Intangible property must be included, 480.
Interest during construction must be considered, 487.
Promotion cost must be included, 481.
Paving cost, when excluded, 501.
Paving cost, when included, 502.
Taxes during construction must be considered, 488.
Working capital must be allowed, 504.

(Numbers refer to sections unless otherwise indicated.)

**Noyes, W. C.**
Creation of value by transportation, 143.
Economic limit of minimum rate, 141.
Maximum and minimum limits of Utility rates, 139.
Monopolies should be supervised, 85.
Risk is always an element of freight rates, 612.
What the traffic will bear, 629.
What the traffic will not bear, 631.

**Snow, C. H.**
Chelura, 336.
Limnoria, 335.
Teredo, 354.
Sphaeroma, 337.

**Snyder, T. E.**
Pole-borers, 338.

**Steinmetz, Charles P.**
Effects of objects on resulting illumination, 661.
Eye fatigue in illumination, 643.
Illumination,
Criterion, 663.
Subjective, 662.
Uniform, wrong, 644.
Intrinsic brilliancy, 664.
Law of lamp distances, 658.
Objective illumination, 660.
Physiological action of light, 642.

**Thresh, John C.**
Iron in water supplies, 800.
Water turbidity, 785.

**Turneaure, F. E.**
Significance of loss on ignition in water, 799.

**U. S. Bureau of the Census,**
How labor cost of Utilities has increased, 98.
Stationary horse power used, 103.

**U. S. Bureau of Corporations,**
Niagara Falls water power, 106.
Stationary horse power used, 103.
Undeveloped water power in U. S., 105.

**U. S. Bureau of Labor,**
Relative prices of commodities, 97.

**United States Supreme Court,**
Appraisal, judicial procedure not necessary in, 471.
Arbitration and appraisal distinguished, 469.
Artificial monopolies are odious, 90.
Artificial monopolies defined, 87.
Classification of charges, criterion for, 570.
Common law, what it includes, 19.
Competition in freight rates,
Lawful to consider, 625.
Test for, 626.
Contract not limited by life of corporation, 237.
Decreased rates and net earnings, 136.
Depreciation,
Complete, 353.
Failure to provide for, is fault of Utility, 315.
Incomplete, 354.
Recognition of, a duty, 314.
Diminution of water supply, 347.
Eminent domain,
Does not destroy contracts, 194.
No exceptions to, 193.
Valuation of condemned property, 196.

(Numbers refer to sections unless otherwise indicated.)

What is, 192.
May be delegated, 195.

Exclusive grants,
Classes of, 239.
Tests for, 238.

Federal constitution,
Supreme in regulation matters, 286.
Federal court may not enjoin State court, 311.
Federal powers over commerce, 287.

Federal government,
Unity of, 185.
Supremacy of, 187.
When state lines cease, 186.

Franchise,
Ambiguous, 208.
Charter protection, 206.
Duties going with, 215.
Eminent domain superior to, 213.
Exclusive grants, 205.
Governmental interest superior to private, 211.
Merely property, 214.
No rights granted by implication, 209.
Open dealing only, sanctioned, 212.
Public given benefit of doubt, 207.
Special privilege must be explicit, 210.
Consideration for, 283.
Not common right, 284.

Fourteenth Amendment,
Applies to delegated power, 234.
Corporations same as persons, 221.
Importance of, 219.
Insures court review, 227.
Insures due process of law, 224.
Insures equal protection of law, 225.
Insures operation of law of land, 226.
Insures equal deal for all, 223.
Insures supremacy of Federal power, 228.

Franchise,
Obligations with acceptance, 285.
States cannot tax Federal, 240.
Status of, 282.
Going concern value, recognition of, 557.

Good will,
Cannot be considered in rate cases, 523.
When it has no value, 521.
Governmental interference, 24.
Governmental power,
When it may be suspended, 243.
Who may surrender, 242.
Gross earnings defined, 75.
Hazard in Utility operation, 128.
Interest rate not uniform, 129.
Law, form and substance of, 20.
Legal monopolies, 89.

Legislation,
Absurd construction precluded, 276.
Court review of, cannot be precluded, 278.
Distinction between judicial acts and, 272.
Effect is test for validity, 281.
Limited to maximum rates, 274.
Must be interpreted rationally, 275.

(Numbers refer to sections unless otherwise indicated.)

Never conclusive, 277.
Presumed correct, 299.
Proper motives for, presumed, 300.
When may be combined with judicial powers, 273.
Legislation cannot,
Impair legal contract, 279.
Stop interstate transportation of States' natural resources, 280
Municipal power,
Independent of statutory provisions, 197.
To build its own water works, 199.
Municipality, when it need not buy old water plant, 203.
Municipality's duty to see that its citizens have adequate water supply, 198.
Nature of Utility service determines cost, 566.
Net earnings defined, 76.
Obligations,
Linked with public interest, 170.
Public, cannot be sold, 171.
Personal and arbitrary powers, 15.
Police powers,
Abuse of, 232.
Limited by Federal constitution, 233.
Scope of, 191.
Supremacy of, 190.
What is, 189.
Promoter, definition of, 74.
Property rights and liberty, 23.
Public and private concern in appraisal, distinguished, 470.
Public interest,
First importance, 172.
In monopoly, 169.
What is, 168.
Rate correctness cannot be determined by
Bonded indebtedness, 268.
Capitalization, 269.
Company action, 266.
General rules, 265.
Gross receipts, 267.
Inter- or intrastate business, 271.
Management results, 270.
Profits, 264.
Rate-fixing power, extent of, 182.
Rate-making is legislative function, 263.
Regulating power,
Active, 174.
Dormant, 176.
Inherent, 173.
May be delegated, 177.
Not new, 178.
Penalties, to enforce, 179.
Precedent for, not necessary, 175.
Regulation, motive for, must be public good, 254.
Regulation must be,
Based on predetermined facts, 249.
Conservative, 247.
Constitutional, 248.
Just, 246.
Regulation must be based on,
Fair value of property, 250.
Just compensation, 253.
Regulation must not
Be arbitrary, 258.

(Numbers refer to sections unless otherwise indicated.)

Be wrongfully administered, 260.
Confiscate, 259.
Contain intimidating penalties, 261.
Discriminate, 257.
Ignore public interest in fair rate, 256.
Needlessly interfere, 262.
Relation of land use and value, 513.
Relief from oppressive regulation,
Court review, 304.
Difficulties in, 306.
Local interest does not preclude Federal intervention, 307.
Duty of courts, 305.
Limitation of court, 312.
Master's finding limited, 308.
Must concern actual state laws, 297.
Jurisdiction, 293.
Court cannot fix rates, 313.
Pretexts not considered, 295.
Illegal contracts excluded, 296.
Rates ought to be tried, 298.
Burden of proof on complainant, 301.
Reproduction cost, recognition of, 474.
Short haul may cost more than long haul, 618.
State cannot discriminate against interstate commerce, 290.
State officers' powers, limits of, 231.
State, when supreme, 188.
State's powers over foreign corporations, 183.
State's rights, limitation of, 229.
U. S. Supreme Court,
Independence of, 309.
Must act, 310.
Utilities are natural monopolies, 90.
Utility contract,
Must be complied with to be protected, 202.
Requires continuous performance, 200.
Utility negligence, damages from, 330.
Utility officials, liability of, 180.
Utility records, power to secure, 181.
Validity of, part of a statute, 184.
Value,
Productiveness determines, 251.
Relation of, and use, 62.
Valuation,
Appreciation must be recognized, 505.
Factors having a direct bearing on, 476.
Factors having no bearing on, 478.
Factors having only secondary bearing on, 477.
Franchise rights must be considered, 516.
Relation of land use and value, 513.
Working capital must be allowed, 504.
Vested right,
Must be protected, 236.
What is, 235.
View of regulation problem, 4.
Water contract, when may be cancelled, 201.
When good will is of no value, 521.
When rate regulating power may be suspended, 243.
**Vail, Theodore N.**
Legislators, ignorance of, 20.
Management requirements, 24.
Public opinion, 5.
Regulation is inevitable, 18.

(Numbers refer to sections unless otherwise indicated.)

**Van Buskirk, L. H.**
Algae growths in water supplies, 342.
**Watkins, G. P.**
Population increase and street car traffic, 145.
Street car strap-hanger, 146.
**Watt, James,**
Horse power determination, 735.
**Weston, R. S.**
Iron in water supplies, 800.
**Whipple, G. C.**
Economic value of human life, 155.
Economic value of soft water, 153.
"Pure and wholesome" water defined, 771-2.
Typhoid bacillus, 810.
Water, degree of hardness, 797.
Water, infected, 782.
Water, polluted, 781.
Water, putrid, 780.
Water, soiled or turbid, 778.
Water, stained or colored, 777.
Water, tainted, 779.
**Wisconsin Railroad Commission.**
Advance payment for Utility service is reasonable, 581.
Cash deposit,
Amount that may be required, 580.
Utility may require, 579.
Competition, failure of, 91.
Cost of rate wars, 92.
Demand factors for electric service, Table 13, p. 249
Discount based on mere quantity is inequitable, 589.
Extension costs, criterion for, 571.
Fire hydrant service, 152.
Going value,
Defined, 536.
Inevitable, 538.
Judicial recognition of, 551.
Justice of, 546.
Liquidation of accrued, 549.
May exist without franchise, 545.
Mere physical plant, 537.
Must be considered in rate cases, 548.
Relation to earnings, 544.
Rights of investors, 547.
What it includes, 539.
Demand factors for electric service, Table 13, p. 249.
Going concern value, definition of, 555.
Good will,
Cannot be considered in rate cases, 523.
When it has no value, 521.
When it may be considered, 522.
How "2,000 candle power" term originated, 667.
Interest and profit distinguished, 127.
Maintenance accounts, 326.
Mere physical plant amounts to but little, 537.
Meters must be furnished by Utility, 597.
Minimum charge,
Absence of, produces discrimination, 593.
Necessary and just, 592.
Object of, 591.
Non-discriminating rate, 584.
Obsolete investment, amortization of, 325.
Rate reductions,
On mere quantity are wrong, 587.

(Numbers refer to sections unless otherwise indicated.)

Unprofitable, are discriminatory, 575.
Relation of renewals and depreciation, 326.
Right and duty of Utility is to minimize losses, 577.
Scope of depreciation reserve, 373.
Security for credit, Utility may require, 578.
Sliding scale based on mere quantity is inequitable, 588.
Stability of Utility securities, 134.
Substitutes for "2,000 candle power arc lamp," 668.
Term "2000 candle power arc lamp" is misnomer, 666.
True relation of Utilities and public, 13.
Utility may penalize delinquent patrons, 582.
Utility may shut off service, 583.
Unpaid service and service cost, 576.
Valuation,
Paving cost, when excluded, 501.
Paving cost, when included, 502.
Piecemeal construction, 503.
Purpose of, 468.
Reconstruction cost and service value, 492.
Sales method of land valuation, 507.
Wattage is not only basis for arc lamp rating, 669.
What going value includes, 539.
When good will is of no value, 521.
When service extensions ought not to be made, 244.
Where good will may be considered, 522.

**Wood, Henry,**
Direct interest in investment increases efficiency, 133.
Limits of governmental interference, 24.
Supremacy of natural law, 81.

**Wyman, Bruce,**
Economics and legal changes, 8.
Monopolies should be recognized, 85.
Public opinion and law, 7.
Utilities may cease giving service, 241.

**Zinsser, Hans,**
Asiatic cholera, 812.
Bacteria, number present, 814.
Colon bacillus, 808.
Dysentery bacillus, 811.

(Numbers refer to sections unless otherwise indicated.)

An index is a necessary implement. Without this an author is but a labyrinth without a clue to direct the reader within.
—Fuller.

Index learning turns no student pale,
Yet holds the eel of science by the tail.
—Pope.

# Subject Index


**Absolute,**
Pressure, 673.
Temperature, 687.
**Accidents, (See depreciation.)**
**Acetylene,**
Specific gravity, 730.
What is, 719.
Yield from carbide, 719.
**Acidity in water, 794.**
**Active power to regulate, 174.**
**Advance payment for Utility service reasonable, 581.**
**Air,**
Atmospheric, 707.
Test for, in gas, 726.
**Algae growths in water supplies, 342.**
**Alkalinity,**
In water, 794.
Sometimes synonymous for temporary hardness, 794.
**Alternating Current,**
Advantages of, 757.
Cannot be used in storage batteries, 757.
Relation to direct current, 757.
What is, 752.
**Alteration in value, defined, 34.**
**Alternations, 755.**
**Altitude,**
Effect on gas apparatus capacity, Table 11, p. 346.
Effect of, on gas apparatus capacity, 690.
**Ambiguous grants, 208.**
**Ammonia,**
Albuminoid in water analysis, 789.
Free, in water, 790.
Test for, 722.
**Amortization,**
Definition of, 30.
Distinction between depreciation and, 33.
Distinction between replacement and, 31.
**Ampere, what is, 744.**
**Animal growths in water mains, 345.**
**Annuity, Table 5, p.**
**Appraisal,**
Distinction between arbitration and, 469.
Distinction between public and private, 470.
Judicial procedure not necessary in, 471.
Synonymous with valuation, 73.


(Numbers refer to sections unless otherwise indicated.)

**Appreciation defined, 35.**

**Arbitration,**
Distinction between appraisal and, 469.
Distinction between public and private, 470.

**Arc Lamp,**
"Two thousand candle power," 666-7-8.
Wattage not only basis for rating, 669.

**Artificial Gas,**
Incorrectly used term, 712.
Service characteristics of, 159.

**Artificial monopolies, defined, 87.**

**Asiatic cholera bacillus, 812.**

**Atmospheric,**
Air 707.
Pressure, 670.

**Average Life,**
Comparison of different methods, 379.

**Bacteria.**
Asiatic cholera, 812.
Belong to vegetable kingdom, 804.
Carried by water, 813.
Classes found in water, 805.
Colon bacillus, 808.
Distinction between germs, microbes and, 803.
Dysentery, 811.
Natural water, 806.
Number present, 814.
Paratyphoid bacillus, 809.
Soil organisms, 807.
Typhoid bacillus, 810.
What are, 802.

**Barometric pressure, 671.**

**Bench gas, incorrectly used term, 712.**

**Bond Discount,**
As a brokerage fee, 483.
As an interest rate element, 482.
As a promotion fee, 484.
Liquidation of, 485.

**Brake horse power, 737.**

**Break-down service defined, 77.**

**Calorific,**
Intensity, 694.
Power, what is, 693.
Value, what is, 693.

**Candle,**
Foot, 654.
Standard, 635.
Standard, defects of, 636.

**Candle Power,**
Definition of, 634.
Determination, 638.
Horizontal, 651.
Mean hemispherical, 653.
Mean spherical, 652.
Relation of direction to, 650.
Standard, 637.
"Two thousand" arc lamp, 666-7-8.
Hour, relative costs, 113.

(Numbers refer to sections unless otherwise indicated.)

**Capital,**
Defined, 36.
Fixed, defined, 37.
Floating, defined, 38.
Mobility of, 125.

**Capitalist, economic importance of, 126.**

**Capitalization,**
Earnings, 529.
How rates are determined, 533.
Methods for determining rates, 531.
Net annual income for, 530.
Rate based on value of securities, 534.

**Car, empty return cost, 147.**

**Carbon Dioxide, 704.**
Test for, 724.

**Carbon Monoxide, 703.**

**Carburreted Water Gas,**
Amount of steam formed in burning, 728.
Specific gravity, 730.
What is, 716.
Yield from coke, 716.

**Cash deposit,**
Amount of, 580.
To insure payment, 579.

**Centigrade scale, 686.**

**Charter, Protection, 206.**

**Chelura, 336.**

**Chlorine, 793.**

**Cholera Bacillus, 812.**

**Circular mil, what is, 738.**

**City Gas, Incorrectly used term, 712.**

**Classification of Charges,**
Always a compromise, 569.
Criterion for, 570.
Duty of Utilities, 567.
Is general, 568.

**Coke oven gas,**
Distinguished from retort coal gas, 713.
Specific gravity, 730.
What is, 713.
Yield of ton of coal, 713.

**Colon bacillus, other names for, 808.**

**Color, typical light sources, 665.**

**Combustion, what is, 698.**

**Commercial gases, 699.**

**Commodities, relative prices of, 97.**

**Commodity and service, distinguished, 121.**

**Common law,**
Development of, 7.
Regulation is form of, 19.

**Competition,**
Failure of, 91.
Possible, relation of, to profits, 138.

**Composite,**
Life, 374.
Life by sinking fund method, 377.
Life by straight line method, 376.
Life determination, 375.
Nature of Utility plants, 372.

**Compound interest, Table 3, p. 240.**

**Condemned property, valuation of, 196.**

**Conduction, 765.**

**Conductors,**
- Electric, classes of, 384.
- Electrolytic, 386.
- Metallic, 385.

**Co-operation between public and Utilities, 10.**

**Consumer expenses, defined, 80.**

**Consumption charge, 574.**

**Continuity of operation, effect on cost of service, 120.**

**Contract,**
- Eminent domain does not destroy, 194.
- Must be complied with to be protected, 202.
- Not limited by life of corporation, 237.
- When municipality may cancel water, 201.
- With Utility requires continuous performance, 200.

**Corporation,**
- Life of, does not limit contract, 237.
- Same as person, 221.
- State power over foreign, 183.

**Cost,**
- Defined, 40.
- Empty car return, 147.
- Extension, defined, 49.
- Extension, significance of, 96.
- Fixed, defined, 50.
- Franchise, ought to be capitalized, 115.
- Intangible, defined, 42.
- Interest during construction, defined, 45.
- Labor, how it has increased for Utilities, 98.
- Maintenance, defined, 54.
- Not synonymous with value, 40.
- Of rate wars, 92.
- Organization, defined, 44.
- Original, defined, 48.
- Physical property, 47.
- Plant, defined, 48.
- Promotion, defined, 43.
- Relation of fixed and variable, 124.
- Removal, factors governing, 64.
- Renewal, defined, 52.
- Repair, defined, 53.
- Replacement, defined, 57.
- Reproduction, defined, 57.
- Running, defined, 51.
- Species of, 41.
- Synonymous with investment, 40.
- Taxes, during construction, 46.
- Telephone, in large and small exchanges, 151.
- Unpaid, 576.
- Use and service, 148.
- Variable, defined, 51.

**Cost of freight service,**
- Extra service justifies higher rates, 607.

**Court review insured, 227.**

**Credit, Utility may ask security for, 578.**

**Crenothrix growths, 344.**

**Current,**
- Alternating, what is, 752.
- Direct, what is, 756.

Custom, relation to public opinion, 6.
Customer charge, 572.
Cycle, what is, in electrical parlance, 753.
Death rate, relation to water supply, 154.
Deferred maintenance, defined, 56.
Definitions,
  Importance of, 27.
  Requirements of, 28.
Delegated,
  Power, 234.
  Power of eminent domain may be, 195.
  Power to regulate may be, 177.
Demand,
  Charge, 573.
  Expenses, defined, 79.
  Factors, electric service, Table 13, p. 249.
Depreciation,
  Accidents from, 328.
  Algae growths cause, 342.
  Allowance is for past obligations, 316.
  Amortization of obsolete investment, 325.
  Animal growths in water mains, 345.
  Arbitrary method decreasing payments, 366.
  Arbitrary method increasing payments, 367.
  Chelura, damage done by, 336.
  Commercial limitation of equipment life, 319.
  Complete, 353.
  Complete and incomplete excluded, 500.
  Deferred maintenance and, 327.
  Definition of, 29.
  Diminution of water supply, 347.
  Distinction between alteration in value and, 34.
  Distinction between amortization and, 33.
  Elements, due to, 331.
  Extraordinary, 351.
  Failure to provide for, is fault of Utility, 315.
  Fifty per cent method, 370.
  Functional, 320.
  Gross earnings basis method, 368.
  Inadequacy, 321.
  Incomplete, 354.
  Insurance method, 371.
  Intangible property, 349.
  Life of property, 355.
  Limnoria, damage due to, 335.
  Methods for providing for, 361.
  Methods of computing, 362.
  Mineral growths in water mains, cause of, 343.
  Natural gas, depletion of, 348.
  Negligence, due to, 329.
  Normal maintenance and, 326.
  Normal wear and, 318.
  Obsolescence, 322.
  Due to exercise of police power, 324.
  Obsolete investment, amortization of, 325.
  Ordinary 350.
  Parasites, damage done by, 333.
  Pole borer, damager done by, 338.
  Rates, 358.
  Rates, fraud in, 360.
  Rates, periodic review of, 359.
  Recognition of, a duty, 314.
  Scope of reserve for, 373.

Service output basis method, 369.
Sinking fund method, 364.
Sinking fund method application, 365.
Sinking fund method illustrated, Fig. 30, p. 122.
Species of, shown in Fig. 20, p. 103.
Sphaeroma, damage done by, 337.
Squirrels, damage done by, 340.
Straight line method, 363.
Structural defects, due to, 332.
Supersession synonymous with, 323.
Teredo, damage done by, 334.
Total, 352.
Vegetable growths in water mains, 344.
Water supply, 341.
What adequate allowance must include, 357.
Wood-peckers, damage done by, 339.

**Depreciation rates,**
Floy's, Table 8, p. 244.
Metcalf's, Table 7, p. 243.

**Differential pressure, what is, 677.**

**Diffusion of gas, 729.**

**Direct current,**
What is, 756.
Relation to alternating current, 757.

**Discount based on mere quantity is inequitable, 589.**

**Dividends,**
Liability for unearned, 132.
Unearned, 131.

**Dormant power to regulate, 176.**

**Double trolley (See under electrolysis.)**

**Doubt, Public given benefit of, 207.**

**Due process of law, definition of, 224.**

**Duplication of investment in competing Utilities, 93.**

**Duties going with franchise, 215.**

**Dysentery bacillus, 811.**

**Earnings,**
Decreased rates and net, 136.
Gross, defined, 75.
Net, defined, 76.

**Economic,**
Importance of capitalist, 126.
Limits of maximum rate, 140.
Limits of maximum rate, 140.
Loss due to infected water, 156.
Value of human life, 155.
Value of soft water 153.

**Economics, legal changes, relation to, 8.**

**Effective heating value, 697.**

**Efficiency, what is, 734.**

**Electricity, relation to Utility problem, 3.**

**Electric power,**
Characteristics of service, 160.
Economic importance of, 102.

**Electrolysis,**
Alternating current, activities of lead and iron, 442.
Alternating current, relation of electrolyte to, 441.
Alternating current, relative electrolytic activity of direct current and, 440.
Bonded cable sheaths are dangerous, 435.
Bursting water mains caused by, 158.

(Numbers refer to sections unless otherwise indicated.)

Cause of, specific, 390.
Coating of mains, 438.
Coating, summary of, 439.
Complete remedy for, 417.
Concrete, iron and steel in, 444.
Conditions necessary for, 391.
Conductors, classes of, 384.
Conductors, electrolytic, 386.
Conductors, metallic, 385.
Corrosion, amount of, 402.
Corrosion, location of, 406.
Corrosion of cast iron, 414.
Corrosion of lead, 415.
Corrosion of wrot iron and steel, 413.
Corrosion, rate of, for iron, 403.
Corrosion, rate of, for lead, 403.
Corrosive tendencies of cast iron, wrot iron and steel, 404.
Court cannot enjoin operation of railway, 465.
Court cannot specify plan of relief, 464.
Current carrying tendencies of cast iron, wrot iron and steel, 405.
Current on underground structures, 397.
Current paths in earth, 409.
Damage, cause of, 460.
Damage, duty to protect against, 462.
Damage, extent of, 458.
Damage, franchise does not authorize, 459.
Damages, indirect, 448.
Damage is due to negligence, 461.
Damages, direct, 449.
Damages, liability for, limited to negligence, 457.
Damage, stray currents do not always produce, 463.
Diagram showing action, Fig. 32, p. 132.
Difficulties of, 383.
Double trolley, data pertaining to Washington, D. C., plant, 420.
Double trolley, extra maintenance cost of, 422.
Double trolley, extra maintenance cost per car, 423.
Double trolley, installation cost, extra per car, 424.
Double trolley, installation cost, extra per mile, 425.
Double trolley, what is, 418.
Double trolley, what it accomplishes, 419.
Double trolley, why installed in Washington, D. C., 421.
Electric circuit, continuity of, 392.
Electric current determination, 412.
Electric current must be known, 411.
Electrolyte, what is, 388.
Electrolytic action, 389.
Elimination, methods of, 416.
Equilibrium law and, 393.
Factors pertaining to damages from, Fig. 38, p. 156.
Fire hazard due to, 447.
Fire insurance rates and, 158.
Importance of, 383.
Joint insulation, 437.
May cause corrosion, 446.
Painting of mains, 438.
Potential districts, 408.
Pure water is non-conductor, 387.
Radial return system, importance of proper copper distribution, 431.
Radial return system requirements, 430.
Radial return system, what it is, 429.
Rail bonding, adequate, 427.
Railway return, 395.
Relation of frequency to corrosion, 443.
Remedial action, 466.
Remedial measures, first aim of, 426.

(Numbers refer to sections unless otherwise indicated.)

Resistance of pipe joints, 407.
Return circuit, continuity of, 428.
Return circuit, what is, 396.
Return on other Utility structures, damages caused by, 434.
Return on other Utility structures, dangers in, 433.
Return on other Utility structures, what is, 432.
Soil constituents, relation of, 399.
Soils, high resistance of, 400.
Stray current, negligible sources, 382.
Stray current, what is, 381.
Street, primary purpose of, 451.
Streets, mutual relations on, 456.
Streets, prior rights on, 454.
Streets, relative rights on, 455.
Streets, Utilities that are a burden, 452.
Streets, Utilities that are not a burden, 453.
Street soils, action of, 398.
Survey, what it should consider, 445.
Temperature, effect of, on, 401.
Use of underground structures of other Utilities is saving to electric railway, 436.
Voltage no criterion, 410.
What is, 380.

**Electrolyte, what is, 388.**

**Electrolytic action, 389.**

**Elevation, effect of, on gas pressure, 681.**

**Eminent domain,**
Does not destroy contracts, 194.
No exceptions to power of, 193.
Power may be delegated, 195.
Superior to franchise rights, 213.
What is power of, 192.

**Empty Car return cost, 147.**

**Energy, creation of value by transmission, 144.**

**Estimates,**
Inacuracy of engineering, 489.
Post-construction, 490.

**Ethene, what is, 702.**

**Ethylene, what is, 702.**

**Excise taxes are burden on consumer, 115.**

**Exclusive grants,**
Classes of, 239.
Rule of construction, 205.
Tests for, 238.

**Expenses,**
Consumer, defined, 80.
Demand, defined, 79.
Output, defined, 78.

**Explosions, gas, caused by electrolysis, 158.**

**Extension cost,**
Criterion for, 571.
Defined, 49.
Significance of, 96.

**Extensions, unprofitable service, need not be made by Utility, 244.**

**Eye fatigue,**
Intrinsic brilliancy and, 664.
What is, 643.

**Fahrenheit scale, 686.**

**Fair market value, defined, 71.**

(Numbers refer to sections unless otherwise indicated.)

**Federal,**
Constitution supreme in regulation matters, 286.
Court may not enjoin State court, 311.
Government, supremacy of, 187.
Government, unity of, 185.
Legislation, hostile, 217.
**Federal Power,**
Extent of, over commerce, 288.
Over commerce, 287.
Supremacy of, 228.
When it applies to intrastate commerce, 292.
**Fire Hydrant, service of waterworks, 152.**
**Fire insurance rates,**
Electrolysis and, 158.
Quality of water and, 157.
**Fixed capital, defined, 37.**
**Fixed Cost.**
Defined, 50.
Relation to variable cost, 124.
**Floating capital, defined, 38.**
**Fluid,**
Choice of, in gas pressure measurement, 675.
Gages, 674.
**Foot candle, definition of, 654.**
**Foreign corporations, State power over, 183.**
**Fourteenth amendment,**
Applies to all classes, 220.
Importance of, 219.
Insures square deal for all, 223.
What it embraces, 218.
**Franchise,**
Consideration for, 283.
Cost of, ought to be capitalized, 115.
Duties going with, 215.
Federal, cannot be taxed by State, 240.
Merely property, 214.
Not common rights, 284.
Obligations with acceptance, 285.
Rights inferior to eminent domain, 213.
Rights must be considered, 516.
Status of, 282.
Valuation for rate cases, 519.
Value, earning power, determines, 518.
Value, factors determining, 517.
**Freight rate,**
Advantage of natural location must be recognized, 622.
Advantage of natural location must not be discriminated against, 624.
Advantage of natural location must not be neutralized, 623.
Advertising description determines class, 600.
Camparisons not safe, 608.
Competiton as a regulator of, 627.
Cost of service cannot be accurately apportioned, 606.
Cost of service less in car loads, 609.
Cost of service not sole criterion, 605.
Cost per mile does not necessarily increase with distance, 615.
Distance not always controlling, 614.
Lawful to consider competition, 625.
Local service costs more than thru, 610.
Minimum charge justified, 611.
Must bear some relation to commodity value, 604.
Must usually consider increase in distance, 617.
Not proportioned to distance, 616.

(Numbers refer to sections unless otherwise indicated.)

One cannot be considered by itself, 628.
Profit included in reasonable, 632.
Relation of carrier's liability, 601.
Relation of terminal charges and distance, 613.
Risk is an element of, 612.
Short haul may cost more than long haul, 618.
Test for competition, 626.
Ton-mile limitations, 621.
Ton-mile no test for local rates, 620.
Ton-mile, status of, 619.
Value of commodity and, 599.
Value of commodity not only test for, 602.
What the traffic will bear, 629-30.
What the traffic will not bear, 631.
When it may fluctuate with commodity value, 603.
When profits may not be included, 633.

**Fuel losses, in Utility plans, 101.**

**Functional depreciation (See Depreciation).**

**Future worths, Table 2, p. 239.**

**Gage**
Fluid for measuring gas pressures, 674.
Pressure, 672.

**Gas,**
Acetylene, 719.
Apparatus, effect of altitude on capacity, 690.
Artificial, service characteristics, 159.
Bench, what term means, 712.
Carbureted water, 716.
City, what term means, 712.
Coke oven, 713.
Density of, 730.
Diffusion of, 729.
Diluents, 720.
Effect of pressure on heating value, 691.
Effect of temperature on heating value, 691.
Flow, laws of, 733.
Gasoline, what is, 718.
Impurities, 720.
Leakage depends on density, 731.
Natural, diminution of supply, 348.
Natural, service characteristics, 162.
Natural, what is, 711.
Neither light nor heat per se, 732.
Pressure, effect of elevation on, 681.
Pressure, effect of fluctuating, on service, 684.
Pressure, effect of, on, 682.
Pressure, factors affecting, 678.
Pressure, law of, 682.
Pressure, maximum, 680.
Pressure, minimum, 679.
Pressure units, 676.
Producer, 714.
Retort coal, what is, 712.
Specific gravity of, 730.
State cannot prevent interstate transportation of, 280.
Storage in pipe lines, 683.
Temperature, effect of, on, 688.
Town, what term means, 712.
Variation in volume due to pressure, Table 10, p. 247.
Water, 715.

**Gases, commercial, 699.**

**Gas explosions, caused by electrolysis, 158.**

**Gasoline Gas,**
Specific gravity of, 730.
What is, 718.
Yield from gasoline, 718.

**Germs, distinguished from bacteria, 803.**

**Going concern value,**
Definition, 555.
Distinguished from going value, 556.
Judicial recognition of, 557.

**Going value,**
Calculation of, 553.
Cost of developing business, 552.
Development cost better term, 536.
Distinguished, 540.
Distinguished from going concern value, 556.
Established business enhances value, 541.
Factors determining, 535.
Judicial recognition of, 551.
Justice of, 546.
Inevitable, 538.
In municipal Utilities, 554.
Liquidation of accrued, 549.
May be capitalized, 550.
May exist without franchise, 545.
Mere physical plant, 537.
Must be considered in fixing rates, 548.
Physical property cost no criterion of, 543.
Relation to earnings, 544.
Rights of investors, 547.
Service connection cost no criterion of, 542.
What is, 536.
What it includes, 539.

**Good will.**
Cannot be considered in rate cases, 523.
Definition of, 520.
When it may have value, 522.
When it is of no value, 521.

**Government,**
Federal, supremacy of, 187.
Interest of, superior to private, 211.
Only open dealing with, sanctioned, 212.
Unity of Federal, 185.

**Governmental,**
Power to regulate, 172.
Power, who may surrender, 242.

**Grants,**
Ambiguous, 208.
Classes of exclusive, 239.
Construction of exclusive, 205.
Never made by implication, 209.
Special privilege must be explicit, 210.
Tests for exclusive, 238.

**Gross Earnings,**
Defined, 75.
Depreciation basis, 368.

**Hazard, defined, 128.**

**Hard water, cost of softening, 153.**

**Hardness of water,**
Degree of, 797.
Permanent, 795.
Temporary, 796.

**Heat Unit, what is, 692.**

(Numbers refer to sections unless otherwise indicated.)

**Heating Power, what is, 693.**
**Heating service, characteristics of, 161.**
**Heating value,**
Effective, 697.
Gas, effect of pressure on, 691.
Gas, effect of temperature on, 691.
Gross, 696.
High, 696.
Low, 697.
Net, 697.
What is, 693.
**Heating values of various gases, Fig. 6, p. 37.**
**Heat loss, due to steam in combustion products, 728.**
**Heat of combustion, what is, 693.**
**Heat unit, relative costs, 113.**
**High heating value, 696.**
**Horse power,**
Brake, 737.
Indicated, 736.
Stationary, developed in U. S., 103.
What is, 735.
**Hostile,**
Federal legislation, 217.
State legislation, 218.
**Human law,**
Conflict with natural, 82.
Not infallible, 82.
**Hydrocarbons, what are, 709.**
**Hydrogen, what is, 700.**
**Illumination,**
Eye fatigue in, 643.
Intrinsic brilliancy, 664.
Objective, 660.
Objects, effects of, on, 661.
Physiological action is criterion, 663.
Subjective, 662.
Uniform, wrong, 644.
What is, 659.
**Illuminants, what are, 710.**
**Implication, no rights granted by, 209.**
**Inadequacy, see Depreciation.**
**Increasing returns, law of, 137.**
**Indicated horse power, 736.**
**Induction, 766.**
**Inherent power to regulate, 173.**
**Insurance,**
Rates for fire and electrolysis, 158.
Rates for fire and quality of water, 157.
**Investment,**
Direct interest in, increases efficiency, 133.
Duplication of, in competing Utilities, 93.
Synonymous with cost, 40.
**Installment payment, Table 6, p. 243.**
**Intangible cost defined, 42.**
**Intangible property, depreciation of, 349.**
**Interest,**
Bond discount as an element of, 482.
Compound, Table 3, p. 240.
Distinguished from profit, 127.
What is public, 168.

(Numbers refer to sections unless otherwise indicated.)

**Interest during construction,**
Defined, 45.
Must be paid, 487.
**Interest rate,**
Not uniform, 129.
Varies with hazard, 130.
**Iron in water,**
Percentage that will give trouble, 801.
Why objectionable, 800.
**Junk value defined, 64.**
**Kilowatt, 748.**
**Kilowatt hour, 749.**
**Kirchoff's law, 394.**
**K. V. A.**
Rating, 760.
Rating and plant capacity, 761.
**Labor cost, how it has increased for Utilities, 98.**
**Lamp, law of distances, 658.**
**Large consumer,**
Reductions to, for mere quantity are wrong, 587.
Status of, 586.
**Latent heat of evaporation,**
Effect on heating value of gas, 697.
Loss in combustion products, 728.
What is, 695.
**Law,**
Common, development of, 7.
Difference between form of, and substance, 20.
Distinction between legislation and, 20.
Due process of, definition, 224.
Equal protection of, 225.
Equilibrium and electrolysis, 393.
Human, conflict with natural, 82.
Human, not infallible, 82.
Natural, conflict with human, 82.
Natural, supremacy of, 81.
Of divided circuits and electrolysis, 394.
Of increasing returns, 137.
Of inverse squares, 646.
Of lamp distances, 658.
Of light direction, 647.
Of light interception, 649.
Of light radiation, 645.
Of light reflection, 648.
Of resistance variation, 745.
Of gas flow, 733.
Of water flow, 769.
Relation to public opinion, 7.
**Law of the land,**
What is, 226.
**Leakage,**
Gas, depends on density, 731.
Relation of gas, air and water, 731.
**Legal changes, economics, relation to, 8.**
**Legal monopolies defined, 89.**
**Legislation,**
Absurd construction precluded, 276.
Cannot impair legal contract, 279.
Cannot stop interstate transportation of gas, 280.
Court review of, cannot be precluded, 278.
Definition of, 20.

Distinction between judicial acts and, 272.
Distinction between regulation and, 272.
Effect is test for validity, 281.
Hostile federal, 217.
Hostile state, 218.
Limited to maximum rates, 274.
Much not accurate English, 20.
Must be interpreted rationally, 276.
Never conclusive, 277.
Not synonymous with regulation, 21.
Presumed correct, 299.
Proper motives for, presumed, 300.
When may be combined with judicial powers, 273.

**Liability, corporation officials, 180.**

**Liberty,**
Does regulation control, 22.
Frenchman's conception of, 22.
Individual rights and, 23.
Little understood, 22.
Puritan's idea of, 22.

**Life of Utility structures,**
Average, 374.
Average, comparison of different methods, 379.
Average, false basis of, 378.
Determination of composite, 375.
Life, economic value of human, 155.

**Life of engineering structures,**
Floy's, Table 8, p. 244.
Metcalf's, Table 7, p. 243.

**Light,**
Beam, 641.
Color of typical courses, 665.
Correct intensity, 657.
Direction and candle power, 650.
Direction, law of, 647.
Intensity, 656.
Interception, law of, 649.
Inverse squares, law of, 646.
Nature of, 639.
Physiological action of, 642.
Radiation, law of, 645.
Ray, 640.
Reflection, law of, 648.

**Limnoria, 335.**

**Load curves, shown, 116.**

**Load factor, defined, 116.**

**Location,**
Importance of correct, 95.
Relation of price and, 142.

**Losses, right and duty of Utility to minimize, 577.**

**Loss on ignition, 799.**

**Low heating value, 697.**

**Lumen, definition of, 655.**

**Maintenance costs, defined, 54.**

**Maintenance,**
Deferred, defined, 56.
Depreciation and deferred, 327.
Distinction between repairs and, 55.
Normal and depreciation, 326.

(Numbers refer to sections unless otherwise indicated.)

**Management,**
Must not be contemplated by regulation, 24.
What it requires, 24.
**Marsh gas, what is, 701.**
**Maximum and minimum limits of rates, 139.**
**Maximum rates, economic limits for, 140.**
**McCluer device, 764.**
**Meters, Utility must furnish, 597.**
**Microbes, distinguished from bacteria, 803.**
**Millivolt, 741.**
**Miner's inch, 768.**
**Minimum and maximum limits of rates, 139.**
**Minimum charge,**
Absence produces discrimination, 593.
Distinction between rental and, 590.
Legal right of, 594.
Monthly basis for, best, 596.
Necessary and just, 592.
Not a penalty, 595.
Object of, 591.
**Monopolies,**
Artificial or social, 87.
Classes of, 86.
Judicial views of, 90.
Legal, 89.
Natural, defined, 88.
**Monopoly,**
Abuse of, 85.
Definition of, 83.
Odium of, 84.
Regulation of, 85.
Regulation of public, 169.
**Municipality's duty to see that citizens have adequate water supply, 198.**
**Municipality,**
When it may cancel water contract, 201.
When it need not buy old water plant, 203.
When it may build its own water plant, 199.
**Natural gas,**
Amount of steam formed in burning, 728.
Creation of value in transmission, 144.
Diminution of supply, 348.
Relation to Utility problem, 3.
Service characteristics, 162.
Specific gravity, 730.
What is, 711.
**Natural Law,**
Conflict with human, 82.
Supremacy of, 81.
**Natural monopolies, defined, 88.**
**Naphthalene,**
Test for, 725.
What is, 708.
**Negligence,**
Damages from Utility, 330.
Depreciation due to, 329.
**Niagara Falls,**
Water power, size of, 106.
**Nitrates, indication of, in water analysis, 792.**
**Nitrites, indication of, in water analysis, 791.**

(Numbers refer to sections unless otherwise indicated.)

**Nitrogen,**
As albuminoid ammonia, 789.
As free ammonia, 790.
As nitrates, 792.
As nitrites, 791.
What is, 706.
**Net earnings,**
And decreased rates, 136.
Defined, 76.
**Net heating value, 697.**
**Normal wear, see depreciation, 318.**
**Obligations,**
Linked with public interest, 170.
Public, cannot be sold, 171.
**Obsolescence, (See Depreciation)**
**Obsolete investment, amortization of, 325.**
**Odium of monopoly, 84.**
**Officials, liability of corporation, 180.**
**Ohm, 743.**
**Ohm's law, 746.**
**Oil gas,**
What is, 717.
Yield from oil, 717.
**Olefiant gas,**
Sometimes included in illuminants, 710.
What is, 702.
**Operation, continuity of, 120.**
**Organization cost,**
Defined, 44.
What it includes, 486.
**Original cost, defined, 48.**
**Output expenses, defined, 78.**
**Overhead charges, 479.**
**Overload, 123.**
**Oxygen,**
Consuming capacity of water, 788.
What is, 705.
**Parasites,**
Chelura, 336.
Depreciation due to, 333.
Limnoria, 335.
Pole-borer, 338.
Sphaeroma, 337.
Teredo, 334.
Wood-peckers, 339.
**Paratyphoid bacillus, 809.**
**Paving cost,**
When excluded, 501.
When included, 502.
**Peak loads, increase cost of service, 118.**
**Peak load service, defined, 117.**
**Penalties, to enforce regulation, 179.**
**Penalty may be exacted from delinquent Utility patrons, 582.**
**Personal nature of telephone service, 150.**
**Physical property cost defined, 47.**
**Plant cost, defined, 48.**

(Numbers refer to sections unless otherwise indicated.)

**Plant worth, defined, 58.**

**Pole-borer, 338.**

**Police power,**
- Abuse of, 232.
- Limited by Federal constitution, 233.
- Obsolescence of equipment due to, 324.
- Scope of, 191.
- Supremacy of, 190.
- What is, 189.

**Population increase and street car traffic, 145.**

**Potential value, defined, 69.**

**Power,**
- Abuse of police, 232.
- Delegated, 234.
- Eminent domain, 192.
- Eminent domain does not destroy contracts, 194.
- Eminent domain may be delegated, 195.
- Eminent domain, no exceptions to, 193.
- Eminent domain superior to franchise rights, 213.
- Extent of rate fixing, 182.
- Factor, 758-9.
- Factors determining value of water, 107.
- In electrical circuit, 758.
- Limitation of rate regulation, 230.
- Limiting value of ample water, 108.
- Limit of state officers', 231.
- Present worth of undeveloped water, 111.
- Saving effected by water, 110.
- Supremacy of Federal, 228.
- Supremacy of police, 191.
- To secure Utility records, 181.
- Value of insufficient water, 109.
- Water at Niagara Falls, 106.
- Water, available in U. S., 105.
- What is police, 189.
- Who may surrender, governmental, 242.

**Power to regulate,**
- Active, 174.
- Delegated, 177.
- Dormant, 176.
- Governmental, 167.
- Independent of statutory provision, 197.
- Inherent, 173.
- Not new, 178.

**Precedent for regulation not necessary, 175.**

**Present worths, Table 1, p. 238.**

**Pressure,**
- Absolute, 673.
- Atmospheric, 670.
- Barometric, 671.
- Differential, 677.
- Effect of elevation on gas, 681.
- Effect of fluctuating, on gas service, 684.
- Effect on heating value of gas, 691.
- Effect of, on gas, 682.
- Factors affecting gas, 678.
- Gage, 672.
- Maximum gas, 680.
- Minimum gas, 679.
- Variation in gas volume due to, Table 10, p. 247.

**Pressure units, Equivalents, Table 9, p. 247.**

(Numbers refer to sections unless otherwise indicated.)

**Price,**
Distinction between value and, 61.
Relation of quantity and, 135.
Relation of location and, 142.

**Prices,**
Average, of Utility services, 99.
Electric service, 99.
Fluctuating of, 491.
Of artificial gas in 172 towns, 99.
Proper unit requirements, 494.
Railroad freight service, 99.
Railroad passenger service, 99.
Relative, of commodities, 97.
Street railway service, 99.
Telephone service, 99.
Unit, importance of correct, 493.

**Primary line, 762.**

**Private interest, inferior to governmental, 211.**

**Producer gas,**
Specific gravity, 730.
What is, 714.
Yield of ton of coal, 714.

**Profit,**
Distinction between interest and, 127.
Relation of, and possible competition, 138.

**Profits,**
No restrictions as to aggregate, 264.
Relation of, to fair and reasonable rates, 11.

**Promotion cost,**
Defined, 43.
Discussed, 74.
Must be considered in valuation, 481.

**Property,**
Character of, only can impart value, 214.
Defined, 39.
Life of, 355.
Physical, cost of, 47.
Physical examination, necessary to estimate life, 356.
Valuation of condemned, 196.
What it embraces, 222.

**Protection from adverse regulation, by charter, 206.**

**Public,**
Co-operation with Utilities, 10.
Given benefit of doubt, 207.
Mutual interest with Utilities, 9.
Obligations cannot be sold, 171.
Reciprocal relation with Utilities, 12.
True relation with Utilities, 13.

**Public Interest,**
Obligations linked with, 170.
Of first importance, 172.
Superior to private, 23.
What is, 168.

**Public Opinion,**
Duties of Utilities regarding, 5.
How it acts, 5.
Not necessarily just or right, 5.
Relation to custom, 6.
Relation to law, 7.
What it is, 5.

(Numbers refer to sections unless otherwise indicated.)

**Public Utility, what term embraces, 1.**
**Quantity of service used,**
Reductions based on mere, are wrong, 587.
Sliding scale based on mere, is inequitable, 588.
Status of large customer, 586.
Discount based on mere, is inequitable, 589.
**Radiation, law of light, 645.**
**Railway return, 395.**
**Rate,**
Correct basis for making, 560.
Distinction between regulation and making, 564.
Economic limit of minimum, 141.
Fallacy of comparative statistics on, 565.
False basis of valuation for making, 559.
Fixing power, extent of, 182.
Regulating power, when may be suspended, 243.
Regulative power, limitation of, 230.
Relation of determination and valuation, 561.
Relation of policy to reductions, 585.
What an adequate, must provide for, 558.
**Rate correctness cannot be determined by**
Bonded indebtedness, 268.
Capitalization, 269.
Company action, 266.
General rules, 265.
Gross receipts, 267.
Inter- or intrastate business, 271.
Management results, 270.
Profits, 264.
**Rate making,**
Is legislative function, 263.
**Rate wars, cost of, 92.**
**Rates,**
Cardinal principles of, 26.
Decreased, and net earnings, 136.
Depreciation, 358.
Depreciation, fraud in, 360.
Depreciation, periodic review of, 359.
Economic limit of maximum, 140.
Fire insurance and electrolysis, 158.
Fire insurance and quality of water, 157.
Maximum and minimum limits, 139.
Public duty linked with fair, 563.
Reasonable, and fair profits, 11.
**Rating, K. V. A., 760.**
**Readiness to serve, defined, 119.**
**Reasonable rates and fair profits, 11.**
**Reciprocal relation of Utility and Public, 12.**
**Records, power to secure Utility, 181.**
**Reflecting powers, Table 12, p. 248.**
**Regulate,**
Governmental power to, 167.
Governmental power to, co-ordinated, Fig. 16, p. 68.
**Regulation,**
Conservatism in, mandatory, 247.
Definition of Utility, 14.
Distinction between legislation and, 21.
Distinction between rate making and, 564.
Does it control liberty, 22.
Extent of rate-fixing, 182.
Form of common law, 19.

Motive for, must be public good, 254.
Must not contemplate management, 24.
Not synonymous with legislation, 21.
Of monopoly, 85.
Penalties to enforce, 179.
Precedent for, not necessary, 175.
Protection of Utilities from adverse, 216.
Public monopoly, 169.
Relief from oppressive, Fig. 19, p. 96.
Requirements, co-ordinated, Fig. 18, p. 87.
Source of, 19.
Standards for, 18.
What caused demand for, 16.
What is not, 15.
What it includes, 19.

**Regulation must be**
Conservative, 247.
Constitutional, 248.
Just, 246.

**Regulation must be based on,**
Fair value of property, 250.
Just compensation, 253.
Predetermined facts, 249.
Reasonable requirements, 255.

**Regulation must not**
Be arbitrary, 258.
Be wrongfully administered, 260.
Confiscate, 259.
Contain intimidating penalties, 261.
Discriminate, 257.
Ignore public's interest in fair rate, 256.
Needlessly interfere, 262.

**Regulating power,**
Independent of statutory provision, 197.
Not new, 178.

**Regulation problem, U. S. Supreme Court view of, 4.**

**Relief from oppressive regulation,**
Actual laws only considered, 297.
Court review, 304.
Crucial point in, 303.
Determining value of property, 302.
Difficulties, 306.
Duty of courts, 305.
Federal court may not enjoin State Court, 311.
Good faith, 294.
Illegal contracts excluded, 296.
Jurisdiction, 293.
Limitation of court, 312.
Local interest does not preclude Federal intervention, 307.
Master's finding limited, 308.
Measures, co-ordination of, 293.
Pretexts not considered, 295.
Proof, burden of, on complainant, 301.
Rates ought to be tried, 298.

**Remedial action,**
Results of, 17.
(See Relief.)

**Renewal costs, defined, 52.**

**Replacement costs, defined, 52 and 57.**

**Repair costs, defined, 53.**

**Replacement, distinction between amortization and, 31**

(Numbers refer to sections unless otherwise indicated.)

**Repairs, distinction between maintenance and, 55.**
**Reproduction cost,**
Defined, 57.
How ascertained, 473.
Judicial recognition of, 474.
**Resale value, defined, 65.**
**Resistance,**
Laws of, 745.
Relative, 743.
**Retort coal gas,**
Specific gravity, 730.
What is, 712.
Yield of ton of coal, 712.
**Returns, law of increasing, 137.**
**Running cost, defined, 51.**
**Safe water, relation to death rate, 154.**
**Salvage value, defined, 65.**
**Scope of police power, 191.**
**Scrap value, defined, 64.**
**Secondary line, 763.**
**Second-foot, 767.**
**Second-hand value, defined, 65.**
**Securities, stability of Utility, 134.**
**Security for Credit, Utility may require, 578.**
**Service,**
Break-down, defined, 77.
Cost and unpaid service, 576.
Effect of fluctuating gas pressure on, 684.
Factors entering into cost of, 562.
Fire hydrant, of waterworks, 152.
May be shut off, 583.
Nature of, determines cost, 566.
Peak load, 117.
Peak load increases cost of, 118.
Personal nature of telephone, 150.
Relation of use to cost of, 148.
Telephone, complexity of, 149.
Utilities may cease giving, 241.
Utility cannot collect for worthless, 204.
Why telephone costs more in large than in small exchanges, 151.
**Service and commodity, distinguished, 121.**
**Service characteristics,**
Artificial gas, 159.
Electric power, 160.
Heating, 161.
Natural gas, 162.
Telegraph, 163.
Telephone, 164.
Transportation, 165.
Water works, 166.
**Service extensions, unprofitable, need not be made by Utility, 244.**
**Service value,**
Defined, 67.
Distinction between wearing and, 68.
**Sliding scale based on mere quantity is inequitable, 588.**
**Sinking fund,**
Annual basis, Table 5, p. 242.
Application of depreciation method, 363.
Definition of, 32.
Depreciation method, 364.
Semi-annual basis, Table 4, p. 241.

(Numbers refer to sections unless otherwise indicated.)

**Smoke nuisance, how solved, 3.**
**Social monopolies, defined, 87.**
**Soft water, economic value of, 153.**
**Soil,**
High resistance of, 400.
**Soils,**
Action in electrolysis, 398.
Relation of constituents to electrolysis, 399.
**Special privilege grants must be explicit, 210.**
**Specific gravity, various gases, 730.**
**Sphaeroma, 337.**
**Squirrels, depreciation from, 340.**
**Standard,**
Candle, 635.
Defects of candle, 636.
Candle power, 637.
**Standard condition, 689.**
**State**
Cannot burden interstate commerce, 289.
Cannot discriminate against interstate commerce, 290.
Cannot tax Federal franchises, 240.
Commerce regulations, limit of, 291.
Legislation hostile, 217.
Where supreme, 188.
**State lines, when they cease, 186.**
**State power over foreign corporations, 183.**
**State rights, limitations of, 229.**
**Stationary horse power developed in United States, 103.**
**Steam in combustion products,**
Always formed when gas is burned, 727.
Loss due to, 728.
**Storage,**
Gas, in pipe lines, 683.
Utility services in general, 122.
**Straight line**
Depreciation method, 363.
Depreciation method illustrated, Fig. 30, p. 122.
**Street car strap hanger, an economic necessity, 146.**
**Street car traffic, relation to population increase, 145.**
**Sulfur, test for, 723.**
**Suppression, (see Depreciation)**
**Statistics, fallacy of comparative, 565.**
**Statute, validity of part of, 184.**
**Stray current,**
Negligible sources, 382.
What is, 381.
**Supremacy**
Of Federal government, 187.
Of Police power, 190.
Where State has, 188.
**Surrender, governmental power, who may, 242.**
**Tar, test for, in gas, 721.**
**Tax, States cannot tax Federal franchises, 240.**
**Taxation,**
Of Utilities, 114.
Values not conclusive, 496.

(Numbers refer to sections unless otherwise indicated.)

**Taxes,**
Excise, are burden on consumer, 115.
**Taxes during construction,**
Defined, 46.
Must be considered in valuation, 488.
**Telegraph service characteristics, 163.**
**Telephone,**
Complexity of equipment, 149.
Increasing importance of, 3.
Personal nature of service, 150.
Service characteristics, 164.
Why service costs more in large than in small exchanges, 151.
**Temperature,**
Absolute, 687.
Definition, 685.
Effect on gas, 688.
Effect of, on heating value of gas, 691.
Scales, 686.
**Teredo, 334.**
**Test for,**
Air, 726.
Ammonia, 722.
Carbon dioxide, 724.
Naphthalene, 725.
Sulfur, 723.
Tar, 721.
**Thermal value, what is, 693.**
**Time,**
Average monthly, between sunset and sunrise, Table 14, p. 249.
Utility lighting service is used, Table 14, p. 249.
**Total solids, 798.**
**Town gas, incorrectly used term, 712.**
**Transportation,**
Creation of value by, 143.
Relation to Utility problem, 3.
Service characteristics, 165.
**Trolley load, current on underground structures and, 397.**
**Tuberculation of water mains, 343.**
**"Two thousand power arc lamp"**
How term originated, 667.
Term is misnomer, 666.
Substitutes for, 668.
**Typhoid bacillus, 810.**
**Unconstitutional statute, cannot be enforced, 231.**
**Unearned dividends,**
Definition of, 131.
Liability for, 132.
**Unit, heat, what is, 692.**
**Units,**
Equivalents of, 751.
Gas pressure, 676.
Pressure, equivalents, Table 9, p. 247.
Used in measuring Utility service, 112.
**Unity of Federal government, 185.**
**Unpaid service and service cost, 576.**

(Numbers refer to sections unless otherwise indicated.)

**U. S. Constitution,**
5th amendment, 217.
14th amendment, 218.
Limits police power, 233.

**Use, cost of service and,** 148.

**Utilities,**
Co-operation with public, 10.
Fair attitude toward, 25.
Limited field for, 94.
May cease giving service, 241.
Mutual interest with public, 9.
Protection of, from adverse regulation, 216.
Reciprocal relation with public, 12.
Taxation of, 114.
True relation with public, 13.
Unfair attitude of some, 16.
Water power development and, 104.

**Utility,**
Cannot collect for worthless service, 204.
Defined, 72.
Factors entering into cost of service, 562.
Plants, composite nature of, 372.
Public, what it embraces, 1.
Rates, cardinal principles of, 26.
Records, power to secure, 181.
Securities, stability of, 134.
Unprofitable service extensions need not be made by, 244.

**Utility officials, attitude of,** 18.

**Utility problem, increasing importance of,** 3.

**Utility regulation, definition of,** 14.

**Utility services,**
Average prices for, 99.
What average family spends for, 100.

**Validity of part of a statute,** 184.

**Valuation,**
Appreciation must be recognized, 505.
Basis for rate making,
False, 559.
True, 560.
Bond discount an interest rate element, 482.
Bond discount as a brokerage fee, 483.
Bond discount as a promotion fee, 484.
Bond discount, liquidation of, 485.
Bonded indebtedness not controlling, 495.
Burden of proof on Utility, 497.
Capitalization, determination of rates for, 531.
Capitalization, how rates are determined, 533.
Capitalization, net annual income for, 530.
Capitalization of earnings, 529.
Capitalization, rate based on value of securities, 534.
Capitalization, requirement of rates for, 532.
Complete and incomplete depreciation excluded, 500.
Condemned property, 196.
Defined, 73.
Engineering estimates, 489.
Factors having a direct bearing on, 476.
Factors having no bearing on, 478.
Factors having only a secondary bearing on, 477.
Franchise, depends on earning power, 518.
Franchise, factors determining, 517.
Franchise, in rate cases, 519.
Franchise rights must be considered, 516.
Good will cannot be considered in rate cases, 523.

(Numbers refer to sections unless otherwise indicated.)

Good will, what is, 520.
Good will, when it is of no value, 521.
Good will, when it may be considered, 522.
Intangible property must be considered, 480.
Invested dividends must be considered, 475.
Interest during construction must be considered, 487.
Land, always difficult, 506.
Land, amount needed, 512.
Land, basis of value, 514.
Land, effect of strategic position, 510.
Land, factors controlling, 509.
Land, mere increase does not justify higher rates, 515.
Land, method of acquiring, 511.
Land, relation of use, 513.
Land, rights of way always high, 508.
Land, sales method of, 507.
Methods of making, 472.
Objects of, 467.
Organization cost must be included, 486.
Past service no criterion, 499.
Paving cost, when excluded, 501.
Paving cost, when included, 502.
Piecemeal construction, 503.
Prices, fluctuation of, 491.
Promotion cost must be included, 481.
Proper unit price requirements, 494.
Purpose of, 468.
Reconstruction cost and service value, 492.
Relation of present service to value, 498.
Reproduction cost, how ascertained, 473.
Reproduction cost, judicial recognition of, 474.
Synonymous with appraisal, 73.
Taxation not conclusive, 496.
Taxes during construction must be considered, 488.
Unit prices, importance of proper, 493.
Water rights, cash basis for, 526.
Water rights, criterion for diversion damages, 524.
Water rights, must be valued alone, 528.
Water rights, present value of, 527.
Water rights, what riparian include, 525.

**Value,**

Alteration in, 34.
Creation of, by transmission of energy, 144.
Creation of, by transportation, 143.
Definition of, 59.
Distinction between price and, 61.
Factors determining water power, 107.
Fair market, defined, 71.
Human life, economic, 155.
Insufficient water power, 109.
Intangible property, 252.
Junk, defined, 64.
Limiting, of ample water power, 108.
Measure of, 60.
Potential, defined, 69.
Productiveness determines, 251.
Resale, defined, 65.
Salvage, defined, 65.
Scrap, defined, 64.
Second-hand, defined, 65.
Service, defined, 67-68.
Species of, 63.
Relation of use and, 62.
Wearing, defined, 66 and 68.

(Numbers refer to sections unless otherwise indicated.)

**Variable cost,**
Defined, 51.
Relation to fixed cost, 124.
**Vested right,**
Must be protected, 236.
What is, 235.
**Vitiation of air,**
Gas, fumes, 727.
Persons, 727.
**Volt,**
Milli, 741.
What is, 739.
**Voltage,**
Fluctuating, effect of, 740.
Generally used, 742.
Relation of weight of conductor and, 739.
**Water,**
Acidity of, 794.
Alkalinity of, 794.
Asiatic cholera dangers, 812-3.
Bacteria carrier, 813.
Clarification, 774.
Classes bacteria found in, 805.
Chlorine in, 793.
Coagulation, 775.
Color, 784.
Colored, what is, 777.
Dysentery dangers, 811, 813.
Economic loss due to infected, 156.
Economic value of soft, 153.
Hardness, degree of, 797.
Iron in, why objectionable, 800.
Laws of flow, 769.
Loss on ignition, significance of, 799.
Natural bacteria in, 806.
Nitrates in, 792.
Nitrites in, 791.
Number bacteria present in, 814.
Odor, 787.
Oxygen consuming capacity, significance of, 788.
Paratyphoid dangers, 809, 813.
Percentage of iron that will give trouble, 801.
Permanent hardness of, 795.
Pure and safe distinguished, 771.
"Pure and wholesome" defined, 771-2.
Pure, is non-conductor, 387.
Purification, complete, 776.
Purity, degree of, 773.
Quality of, and fire insurance rates, 157.
Relation of safe, to death rate, 154.
Sediment, 786.
Soiled, what is, 778.
Stained, what is, 777.
Tainted, what is, 779.
Temporary hardness, 796.
Total solids, 798.
Turbid, what is, 778.
Turbidity, 785.
Typhoid dangers, 810, 813.
What is, 770.
**Water analysis, significance of, 783.**
**Water borne disease, relation to Utility problem, 3.**

(Numbers refer to sections unless otherwise indicated.)

**Water gas,**
Specific gravity, 730.
What is, 715.
Yield of, from coke, 715.

**Water main growths,**
Animal, 345.
Bryozoa, 345.
Crenothrix, 344.
Mineral, 343.
Removal of, results, 346.
Sponge, 345.
Tuberculation, 343.
Vegetable, 344.

**Water power,**
Available, undeveloped in U. S., 105.
Development and Utilities, 104.
Factors determining value of, 107.
Limiting value of ample, 108.
Niagara Falls, 106.
Present worth of undeveloped, 111.
Saving effected by, 110.
Value of insufficient, 109.

**Water right, present value of, 527.**

**Water rights,**
Cash basis for, 526.
Criterion for diversion damages, 524.
Must be valued alone, 528.
What riparian include, 525.

**Water supply,**
Algae growths in, 342.
Depreciation of, 341.
Diminution of, 347.
Municipality's duty to see that citizens have adequate, 198.
Must be adequate at all times, 198, 200.
When municipality may cancel contract, 201.

**Water works,**
Fire hydrant, service of, 152.
Service characteristics, 166.

**Watt, 747.**

**Wattage, not only basis for rating arc lamps, 669.**

**Wearing value,**
Defined, 66.
Distinction between service and, 68.

**Wood borers,**
Chelura, 336.
Depreciation due to, 333.
Limnoria, 335.
Pole-borer, 338.
Species of, 333.
Sphaeroma, 337.
Teredo, 334.
Wood-peckers, 339.

**Worth, plant, defined, 58.**

**Worths,**
Future, Table 2, p. 239.
Present, Table 1, p. 238.

(Numbers refer to sections unless otherwise indicated.)

"The end of a discourse is better than the beginning."
—Solomon.

**Water gas,**
Specific gravity, 730.
What is, 713
Yield of, from coke, 715.

**Water main growths,**
Animal, 345.
Bryozoa, 345.
Crenothrix, 344.
Mineral, 343.
Removal of, results, 340.
Sponge, 345.
Tuberculation, 343.
Vegetable, 344.

**Water power,**
Available, undeveloped in U. S., 103.
Development and Utilities, 104.
Factors determining value of, 107.
Limiting value of ample, 108.
Niagara Falls, 106.
Present worth of undeveloped, 111.
Saving effected by, 110.
Value of insufficient, 103.

**Water right, present value of, 527.**

**Water rights,**
Cash basis for, 529.
Criterion for diversion damages, 534.
Must be valued alone, 529.
What riparian include, 529.

**Water supply,**
Algae growths in, 342.
Depreciation of, 341.
Diminution of, 347.
Municipality's duty to see that citizens have adequate 193.
Must be adequate at all times, 198, 200
When municipality may cancel contract, 201.

**Water works,**
Fire hydrant, service of, 152.
Service characteristics, 166.

**Watt, 747.**

**Wattage, not only basis for rating arc lamps, 669.**

**Wearing value,**
Defined, 66.
Distinction between service and, 65.

**Wood borers,**
Chelura, 336.
Depreciation due to, 337.
Limnoria, 335.
Pole-borer, 338.
Species of, 333
Sphaeroma, 337.
Teredo, 334.
Wood-peckers, 339

**Worth, plant, defined, 59.**

**Worths,**
Future, Table 2, p 529.
Present, Table 1, p. 528.

(Numbers refer to sections unless otherwise indicated.)

"The end of a discourse is better than the beginning."
—Solomon.

UNIVERSITY OF CALIFORNIA LIBRARY
BERKELEY

Return to desk from which borrowed.
This book is DUE on the last date stamped below.

29Jan'58MW

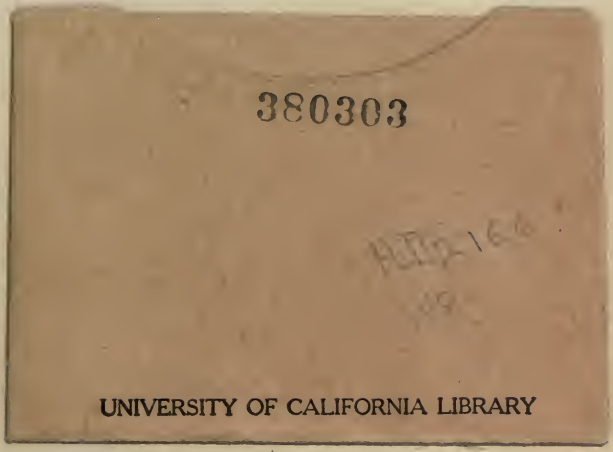
7Jan'60FW

RECD LD

JAN 4 1960

LD 21-100m-11,'49(B7146s16)476

YC 26480


380303

UNIVERSITY OF CALIFORNIA LIBRARY